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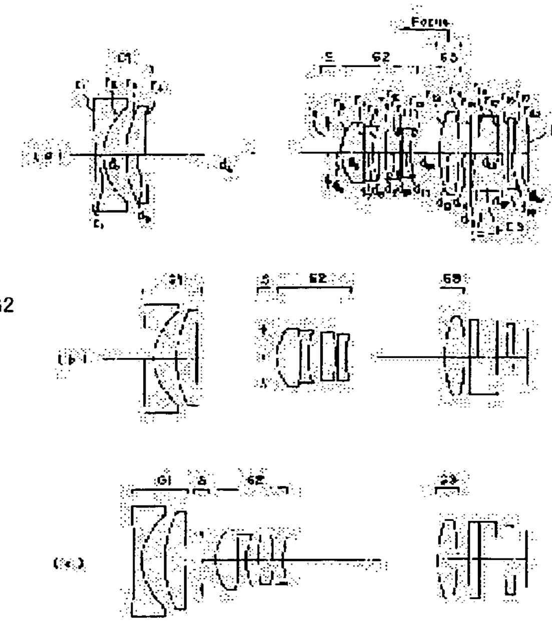
(54) ZOOM LENS AND ELECTRONIC IMAGE PICKUP DEVICE HAVING THE SAME

(57)Abstract:
PROBLEM TO BE SOLVED: To make a video camera and a digital camera drastically thinner by using a zooming system which has a smaller number of lens pieces, can be easily made smaller and simpler and has high image formation performance.
SOLUTION: A zoom lens consists of a negative first group G1, an aperture diaphragm S, a positive second group G2, and a positive third group G3. In performing power variation from a wide angle end to a telephoto end, the second group G2 is moved only to an object side, and the third group G3 is moved while changing its interval with the second group G2. The second group G2 consists of a positive lens, a negative lens, a positive lens and a negative lens. At least either a positive lens or a negative lens of an image side in the second group G2 has an aspheric surface, and satisfies a condition (1) concerning the ratio of a radius of curvature on the optical axis of the surface of the object side of the positive lens of the object side of the second group G2 to that of the surface of an image side of the negative lens of the object side.



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CLAIMS

[Claim(s)]

[Claim 1] The 1st lens group which has negative refractive power in order [side / body], and the 2nd lens group which has forward refractive power, Consist of the 3rd lens group which has forward refractive power, and the variable power from the wide angle edge at the time of an infinite distance object point focus to a tele edge is faced. Said 2nd lens group moves only to a body side, and it moves, said 3rd lens group changing spacing with the 2nd lens group. Said 2nd lens group Sequentially from a body side, it consists of a positive lens L21, a negative lens L22, a positive lens L23, and a negative lens L24. It is the zoom lens characterized by for which lens having the aspheric surface and satisfying the following conditions (1) of the positive lens L23 in said 2nd lens group, or a negative lens L24 at least.

(1) 0.6<R22R/R21F <2.2 however R21F, and R22R It is the radius of curvature on the optical axis of the field by the side of the body of the positive lens L21 of the 2nd lens group, and the field by the side of the image of the negative lens L22 of the 2nd lens group, respectively.

[Claim 2] The claim 1 written zoom lens characterized by uniting with the electronic image sensor arranged on an image side.

[Claim 3] In the zoom lens arranged on the image pick-up side side of an electronic image sensor said zoom lens The 1st lens group which has negative refractive power in order [side / body], and the 2nd lens group which has forward refractive power, Consist of the 3rd lens group which has forward refractive power, and the variable power from the wide angle edge at the time of an infinite distance object point focus to a tele edge is faced. Said 2nd lens group moves only to a body side, and it moves, said 3rd lens group changing spacing with the 2nd lens group. Said 2nd lens group Sequentially from a body side, it consists of a positive lens L21, a negative lens L22, a positive lens L23, and a negative lens L24. It is the zoom lens characterized by for which lens having the aspheric surface and satisfying the following conditions (2) of the positive lens L23 in said 2nd lens group, or a negative lens L24, (3), and (4) at least.

(2) 0< (C24F-C23R) and L<1.6 (3) 0.01<d23 / L< 0.2 (4) It corrects -0.4<L/f2R<0.8. C23R =1/R23R, and C24F =1/R24F it is -- here R23R and R24F, respectively The field by the side of the image of the positive lens L23 of the 2nd lens group, The radius of curvature on the optical axis of the field by the side of the body of the negative lens L24 of the 2nd lens group and L The diagonal length of the effective image pick-up field (abbreviation rectangle) of an image sensor (mm), Optical-axis absentminded mind spacing of the positive lens L23 of the 2nd lens group and a negative lens L24 and f2R of d23 are the synthetic focal distances of the positive lens L23 of the 2nd lens group, and a negative lens L24.

[Claim 4] Electronic image pick-up equipment characterized by having the zoom lens of three given in any 1 term from claim 1.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the electronic image pick-up equipment or the zoom lenses which realized thin shape-ization of the depth direction by the device of optical-system parts, such as a zoom lens, especially, such as a video camera and a digital camera, about the electronic image pick-up equipment which has a zoom lens and it. Moreover, the zoom lens is related with the thing which made the rear focus become possible.
[0002]
[Description of the Prior Art] In recent years, the digital camera (electronic camera) has attracted attention as a next-generation camera which replaces 35mm film (common-name Leica version) camera of silver salt. Furthermore, it has many categories increasingly in the range where a business-use highly efficient type to a portable spread type is broad.
[0003] In this invention, it is aiming at offering the technique of realizing a video camera with thin depth, and a digital camera, securing high definition especially paying attention to a category portable spread type. it is the greatest neck making the depth direction of a camera thin -- optical system, especially a zoom lens system -- it is thickness most from the field by the side of a body to an image pick-up side. Recently, it is in use to adopt the so-called collapsible mount type lens-barrel which pushes out optical system out of a camera body at the time of photography, and contains optical system in a camera body at the time of carrying.
[0004] However, the thickness at the time of optical-system collapsing changes greatly with the lens types and filters to be used. Even if especially the so-called forward precedence mold zoom lens with which the lens group by the side of a body has forward refractive power most in order for a zoom ratio, an F value, etc. to set up a specification highly has large thickness and DEDDO tooth space of each lens element and they collapse it, thickness does not so much become thin (JP,11-258507,A). With a negative precedence mold, although especially the zoom lens of 2 thru/or 3 group configurations is advantageous in that respect, also when the lens by the side of a body is a positive lens most, even if there is much configuration number of sheets in a group, or the thickness of an element is large, or it collapses, it does not become thin (JP,11-52246,A). The image formation engine performance which was suitable for electronic image sensors while being known now, and includes a zoom ratio, a field angle, an F value, etc. is good, and although it has possibility that collapsing thickness can be made the thinnest, there are things, such as JP,11-287953,A, JP,2000-267009,A, and JP,2000-275520,A, as an example.
[0005] Although it is good to make an entrance pupil location shallow for making the 1st group thin, for that purpose, the scale factor of the 2nd group will be made high. It increases [it not only becomes difficult for the burden of one side, therefore the 2nd group to become large, and to make itself thin, but / effectiveness of the difficulty of aberration amendment or a manufacture error] and is not desirable. Although what is necessary is just to make an image sensor small in order to carry out thin-shape-izing and a miniaturization, in order to consider as the same number of pixels, it is necessary to make a pixel pitch small, and the lack of sensibility must be covered by optical system. The effect of diffraction is also ****.
[0006] Moreover, in order to make it a camera body with thin depth, it is effective on the layout of a drive system to perform lens migration at the time of a focus not in a pre-group but in the so-called rear focus. Then, the need that the aberration fluctuation when carrying out a rear focus chooses little optical system comes out.
[0007]
[Problem(s) to be Solved by the Invention] This invention is made in view of such a situation of the conventional technique. The purpose There is little configuration number of sheets and it is easy to make it simple by device layout top small, such as a rear focus method. The zoom method or zoom configuration which has the high image formation engine performance stabilized from the infinite distance to the short distance is chosen. Further It is making each lens element of a zoom lens thin, and attaining thorough thin shape-ization of a video camera or a digital camera also in consideration of selection of filters in making total thickness of each group thin ****.
[0008]
[Means for Solving the Problem] In order to attain the above-mentioned purpose, the zoom lens of this invention The 1st lens group which has negative refractive power in order [side / body], and the 2nd lens group which has forward refractive power, Consist of the 3rd lens group which has forward refractive power, and the variable power from the wide angle edge at the time of an infinite distance object point focus to a tele edge is faced. Said 2nd lens group moves only to a body side, and it moves, said 3rd lens group changing spacing with the 2nd lens group. Said 2nd lens group Sequentially from a body side, it consists of a positive lens L21, a negative lens L22, a positive lens L23, and a negative lens L24. It is characterized by for which lens having the aspheric surface and satisfying the following conditions (1) of the positive lens L23 in said 2nd lens group, or a negative lens L24 at least.
[0009]
(1) $0.6<R22R/R21F<2.2$ however R21F, and R22R It is the radius of curvature on the optical axis of the field by the side of the body of the positive lens L21 of the 2nd lens group, and the field by the side of the image of the negative lens L22 of the 2nd lens group, respectively.
[0010] In this case, it is desirable to unite with the electronic image sensor arranged on an image side.
[0011] In the zoom lens with which the zoom lens of this invention is arranged on the image pick-up side side of an electronic image sensor moreover, said zoom lens The 1st lens group which has negative refractive power in order [side / body], and the 2nd lens group which has forward refractive power, Consist of the 3rd lens group which has forward refractive power, and the variable power from the wide angle edge at the time of an infinite distance object point focus to a tele edge is faced. Said 2nd lens group moves only to a body side, and it moves, said 3rd lens group changing spacing with

the 2nd lens group. Said 2nd lens group Sequentially from a body side, it consists of a positive lens L21, a negative lens L22, a positive lens L23, and a negative lens L24. It is characterized by for which lens having the aspheric surface and satisfying the following conditions (2) of the positive lens L23 in said 2nd lens group, or a negative lens L24, (3), and (4) at least.
[0012]
(2) 0< (C24F-C23R) and L<1.6 (3) 0.01<d23 / L< 0.2 (4) It corrects -0.4<L/f2R<0.8. C23R =1/R23R, and C24F =1/R24F it is -- here R23R and R24F, respectively The field by the side of the image of the positive lens L23 of the 2nd lens group, The radius of curvature on the optical axis of the field by the side of the body of the negative lens L24 of the 2nd lens group and L The diagonal length of the effective image pick-up field (abbreviation rectangle) of an image sensor (mm), Optical-axis absentminded mind spacing of the positive lens L23 of the 2nd lens group and a negative lens L24 and f2R of d23 are the synthetic focal distances of the positive lens L23 of the 2nd lens group, and a negative lens L24.
[0013] This invention contains electronic image pick-up equipment equipped with these zoom lenses.
[0014] Hereafter, the reason and operation which take the above-mentioned configuration in this invention are explained.
[0015] The 1st lens group which has negative refractive power in order [side / body] in this invention, It consists of the 2nd lens group which has forward refractive power, and the 3rd lens group which has forward refractive power. The variable power from a wide angle edge to a tele edge at the time of an infinite distance object point focus The monotonous migration by the side of the body of the 2nd lens group, In the zoom lens performed by migration of a different amount from the 2nd lens group of the 3rd lens group, the 2nd lens group has adopted the zoom lens constituted from the positive lens L21, a negative lens L22, a positive lens L23, and a negative lens L24 sequentially from a body side.
[0016] In addition, in this invention, the lens which consists of a medium with a single lens is made into one unit, and a cemented lens means what consists of two or more lenses.
[0017] in 2 group zoom of **** often used as a zoom lens for silver salt film cameras for many years, although it is good to make high the scale factor of the forward back group (the 2nd lens group) in each focal distance since it is miniaturized therefore One positive lens is added to the pan of the 2nd lens group as the 3rd lens group at an image side, and in case variable power is carried out to a tele edge from a wide angle edge, the method of changing spacing with the 2nd lens group is learned well. Moreover, this 3rd lens group has possibility that it can be used also as an object for focuses. and achievement of the purpose of this invention, i.e., the lens section total thickness at the time of collapsing receipt, -- thin -- carrying out -- in addition -- and in case a focus is carried out by the 3rd lens group, in order to control fluctuation of the aberration outside a shaft including astigmatism, sequentially from a body side, it is indispensable requirements to add and constitute a positive lens at least in a positive lens, a negative lens, and this, and the 2nd lens group is good to add a negative lens to an image side further.
[0018] The balance collapses and is not desirable, if the astigmatism which remains by the 1st lens group and the 2nd lens group in order to take out the effectiveness if the aspheric surface of the amount beyond the need goes into the 3rd lens group will be amended by the 3rd lens group and the 3rd lens group moves here for a focus, although aberration fluctuation becomes a problem when carrying out a focus by the 3rd lens group. Therefore, when carrying out a focus by the 3rd lens group, it must continue throughout a zoom and astigmatism must be cut with the 1st lens group and the 2nd lens group abbreviation picking. Therefore, the 3rd lens group is constituted from a spherical-surface system or a small amount of aspheric surfaces, an aperture diaphragm is allotted to the body side of the 2nd lens group, and the 2nd lens group is good to constitute in order of a positive lens, a negative lens, a positive lens, and a negative lens. Moreover, since a front ball diameter cannot become large easily by this type, it is hard to generate the dead space at the time of collapsing it is not only simpler on a device to make an aperture diaphragm into the 2nd lens group and one (for it to arrange in the example of after-mentioned this invention just before the 2nd lens group, and for them to be the 2nd lens group and one), but, and the F value difference of a wide angle edge and a tele edge is small. Moreover, it is better to make these a cemented lens, since generating of the aberration according [the positive lens and negative lens by the side of the body of the 2nd lens group] to those relative eccentricity is remarkable. When making it junction, it is good to cancel aberration as much as possible within a cemented lens (a positive lens L21, negative lens L22), and to make eccentric sensitivity small.
[0019] Then, it is good to satisfy the following conditional expression about the positive lens 21 of the 2nd lens group, and a negative lens L22.
[0020]
(1) 0.6<R22R/R21F <2.2 however R21F, and R22R It is the radius of curvature on the optical axis of the field by the side of the body of the positive lens L21 of the 2nd lens group, and the field by the side of the image of the negative lens L22 of the 2nd lens group, respectively.
[0021] Although it is advantageous to amendment of the spherical aberration, the comatic aberration, and the astigmatism of whole system aberration if 2.2 of the upper limit of conditions (1) is exceeded, there is little effectiveness of relaxation of the eccentric sensitivity by junction. If 0.6 of a minimum is exceeded, amendment of the spherical aberration, the comatic aberration, and the astigmatism of whole system aberration will tend to become difficult.
[0022] In addition, it is more good to make it be the following.
[0023]
(1-1) It is best for 1.0<R22R/R21F <2.0 pan to make it be the following.
[0024]
(1-2) It is good to be satisfied with 1.4<R22R/R21F <1.8 pan of the following conditional expression about the positive lens L23 and negative lens L24 of the 2nd lens group.
[0025]
(2) 0< (C24F-C23R) and L<1.6 (3) 0.01<d23 / L< 0.2 (4) It corrects -0.4<L/f2R<0.8. C23R =1/R23R, and C24F =1/R24F it is -- here R23R and R24F, respectively The field by the side of the image of the positive lens L23 of the 2nd lens group, The radius of curvature on the optical axis of the field by the side of the body of the negative lens L24 of the 2nd lens group and L The diagonal length of the effective image pick-up field (abbreviation rectangle) of an image sensor (mm), Optical-axis absentminded mind spacing of the positive lens L23 of the 2nd lens group and a negative lens L24 and f2R of d23 are the synthetic focal distances of the positive lens L23 of the 2nd lens group, and a negative lens L24.
[0026] If 0 of the lower limit of conditions (2) is exceeded, it will be easy to generate spherical aberration, and if 1.6 of a upper limit is exceeded, astigmatism cannot be amended even if it introduces the aspheric surface into the 1st lens group.
[0027] It aims at using effectively because of aberration amendment of the configuration of a field where both adjoin, without joining the positive lens L23 and negative lens L24 of the 2nd lens group in this invention. If 0.01 of the lower limit of conditions (3) is exceeded, field interference of a positive lens L23 and a negative lens L24 will tend to reach even in an effective diameter. If 0.2 of a upper limit is exceeded, the diameter of a lens will tend to become thick.
[0028] It is better to have made it become a forward value in that case, in order to make it more convenient [to concentrate eccentric sensitivity on a positive lens L21 and a negative lens L22], when an exit pupil location will approach the image

surface, and will tend to cause shading and it will consider a positive lens L21 and a negative lens L22 as junction, if −0.4 of the lower limit of conditions (4) is exceeded, when it could do. If 0.8 of a upper limit is exceeded, it will be hard to secure a small and high zoom ratio.
[0029] In addition, it is more good to make either or the plurality of condition (2) - (4) be the following.
[0030]
(2) ' 0.15< (C24F−C23R) and L<1.3 (3) ' 0.01<d23 / L< 0.15 (4) ' It is still better for −0.3<L/f2R<0.5 pan to make either or the plurality of condition (2) - (4) be the following. It is best to make especially all be the following.
[0031]
(2) -- " 0.3 < (C24F−C23R) and L< 1(3)" d23 / 0.01<L<0.1(4)" −0.2 -- < -- L/f2R<0.2 -- again The aspheric lens for aberration amendment is good for the 1st lens group one sheet and to consider in the 2nd lens group as a total of three sheets in the whole system of two sheets for spherical aberration because of distortion aberration, astigmatism, and comatic-aberration amendment. Even if it puts in more than it, there is little effectiveness and it only becomes cost quantity.

[0032] Moreover, it is good about axial overtone aberration or chromatic-aberration-of-magnification amendment to fulfill the following conditions.
[0033]
(5) 25<nu21−nu22+nu23−nu24<55, however nu21, nu22, nu23 and nu24 are the Abbe numbers (d line standard) of the medium of the positive lens L21 of the 2nd lens group, a negative lens L22, a positive lens L23, and a negative lens L24, respectively.
[0034] If the lower limit 25 of conditions (5) is exceeded, axial overtone aberration and the chromatic aberration of magnification will tend to become the lack of amendment, and these will tend to become overamendment if 55 of a upper limit is exceeded.
[0035] In addition, it is more good to make it be the following.
[0036]
(5) ' It is best for 25<nu21−nu22+nu23−nu24<50 pan to make it be the following.
[0037]
(5) " It is good to satisfy the following conditions about the aspheric surface of 30<nu21−nu22+nu23−nu24<50 next the positive lens L23 of the 2nd lens group, and a negative lens L24.
[0038]
(6) 7.5x10−3 and L>|Asp2R |>|Asp21F| -- however Asp21F and Asp2R, respectively The field by the side of the body of a positive lens L21, As opposed to the spherical surface which has the radius of curvature on the optical axis of the field of a positive lens L23 or a negative lens L24 The height from an optical axis is the diagonal length (mm) of the effective image pick-up field (abbreviation rectangle) of an image sensor, and the amount of aspheric surface deflections in 0.3L and L set amount Aspof aspheric surface deflections21F to 0, when the body side face of a positive lens L21 is the spherical surface.
[0039] That is, as the amount of aspheric surface deflections as used in the field of this invention is shown in drawing 13 , when setting the diagonal length of the effective image pick-up field of an electronic image sensor to L to the spherical surface (criteria spherical surface) which has the radius of curvature r on the optical axis of the target aspheric surface, the height from an optical axis says the amount of deflections of the aspheric surface in the location of 0.3L.
[0040] Like conditions (6), unless it introduces a certain amount of aspheric surface into a positive lens L23 or a negative lens L24, spherical aberration, comatic aberration, and astigmatism cannot fully amend. If there is whenever [less / aspheric surface] than a positive lens L21, amending [of comatic aberration and astigmatism] will be easy to become inadequate. It becomes [the eccentric sensitivity of a positive lens L23 or a negative lens L24 becomes large too much, and / components precision or assembly precision] severe and is not desirable if 7.5x10−3 and L of the upper limit are exceeded. In addition, the spherical surface is sufficient as the field by the side of the body of a positive lens L21.
[0041] In addition, it is more good to make it be the following.
[0042]
(6) ' 5.0x10−3 and L> It is best for a |Asp2R |>|Asp21F| pan to make it be the following.
[0043]
(6) -- " 2.5x10−3 and L>|Asp2R |>|Asp21F| -- it is more good as another conditions to fill the following.
[0044]
(6-2) It is best for |Asp2R |>3 and a |Asp21F| pan to make it be the following.
[0045]
(6-3) When the following conditions are further satisfied to a |Asp2R |>6, |Asp21F|, and conditions (2) system, the amendment top of spherical aberration is good.
[0046]
(7) −0.5<(R21F−R22R)/(R21F+R22R) <0.3 however R21F, and R22R It is the radius of curvature on the optical axis of the field by the side of the body of the positive lens L21 of the 2nd lens group, and the field by the side of the image of a negative lens L22, respectively. Incidentally, this conditional expression has the inverse number of the usual shape factor.
[0047] If −0.5 of the minimum of this condition is exceeded, it will be easy to become the lack of spherical-aberration amendment, and lens thickness will tend to become thick. Moreover, the workability of the body side positive lens L21 also gets worse. If 0.3 of an upper limit is exceeded, conversely high order spherical aberration will occur, or the workability of the deep concave surface by the side of a negative lens will get worse.
[0048] In addition, it is more good to make it be the following.
[0049]
(7) -- ' −0.4<(R21F−R22R)/(R21F+R22R) <0.2 -- it is still better to make it be the following.
[0050]
(7) -- " −0.3<(R21F−R22R)/(R21F+R22R) <0.1 -- again -- a condition (2) system or (7) systems -- receiving -- the conditions of further the following -- any of (8) and (9) -- or if both are satisfied, it is advantageous about an exit pupil location, i.e., shading.
[0051] (8) −1<f3/f2R<1.6 (9) It corrects 0.02<d22/L<0.5. f2R and f3, respectively The synthetic focal distance of the positive lens L23 of the 2nd lens group, and a negative lens L24, and the focal distance of the 3rd lens group, d22 is spacing of the image side face of the negative lens L22 of the 2nd lens group, and the body side face of a positive lens L23, and L is the diagonal length (mm) of the effective image pick-up field (abbreviation rectangle) of an image sensor.
[0052] Although it is advantageous to the exit pupil location, i.e., shading, in a wide angle edge if 1.6 of the upper limit of conditions (8) is exceeded, the amount of fluctuation of the exit pupil location at the time of carrying out variable power to a tele edge is large, and becomes disadvantageous for shading in a tele edge. When −1 of a lower limit is exceeded, in case a focus is carried out by the point and the 3rd lens group which the exit pupil in a wide angle edge is too near, and shading

tends to generate, the movement magnitude becomes large too much, and there is disadvantage on a tooth space. Moreover, since it is necessary to strengthen the positive lens by the side of the image of the high 2nd lens group of the axial Uemitsu line quantity in paraxial, the principal point location of the 2nd lens group moves back, it is difficult to get and the 1st lens group tends to grow a high scale factor large.

[0053] If 0.02 of the minimum of conditions (9) is exceeded, it will be easy to generate shading influenced by amendment of astigmatism, and the exit pupil location in a wide angle edge. If 0.5 of an upper limit is exceeded, the thickness of the 2nd lens group will be thick and will serve as fetters making [of collapsing thickness] it small.

[0054] In addition, the 2nd The effectiveness to the performance degradation of a relative-position error with the subgroup which put together the subgroup and positive lens L23 which put together the positive lens L21 and negative lens L22 of a lens group, and the negative lens L24 [small] (However, as for the amount of aspheric surfaces of a positive lens L23, it is desirable to make it more smallish in that case.) You may make it the structure which prepares fixed spacing or changing spacing more greatly at the time of variable power and an image pick-up, and is contracted by that only at the time of collapsing. It is advantageous to engine-performance reservation of a periphery to enlarge d22 slightly at the time of an image pick-up.

[0055] In addition, it is more good to make it be the following in both conditions (8) and (9). [both / either or]

[0056]

(8) ' -0.7<f3/f2R<1.0(9)' 0.04<d22 It is still better for /L<0.4 pan to make it be the following in both conditions (8) and (9). [both / either or] It is best to make especially both be the following.

[0057]

(8) " -0.4<f3/f2R<0.4(9)" 0.06<d22 If the following conditions are independently satisfied further to conditions (2) or (5) as be fastidious /L<0.3, it is advantageous to the miniaturization at the time of collapsing.

[0058] (10) -1<f2 F/R21R <2.5, however R21R The radius of curvature of the field by the side of the image of the positive lens L21 of the 2nd lens group and f2F are the synthetic focal distances of the positive lens L21 of the 2nd lens group, and a negative lens L22.

[0059] Although it will be easy to make thin total thickness of the positive lens L21 and negative lens L22 of the 2nd lens group if 2.5 of the upper limit of conditions (10) is exceeded, amendment of axial overtone aberration becomes difficult. Although it is advantageous to amendment of axial overtone aberration if -1 of a lower limit is exceeded, a thick kink colander is not obtained for the total thickness of the positive lens L21 and negative lens L22 of the 2nd lens group, but it becomes fetters making collapsing thickness thin.

[0060] In addition, it is more good to make it be the following.

[0061]

(10) ' It is best for -0.8<f2 F/R21R <0.8 pan to make it be the following.

[0062]

(10) " If the following conditions are further satisfied to -0.6<f2 F/R21R <said 0.5 condition (2) system, (7) system, or (10) system, it is advantageous to the miniaturization at the time of collapsing.

[0063] (11) -0.5<f2/f2R<1, however f2 The synthetic focal distance of the whole 2nd lens group and f2R are the synthetic focal distances of the positive lens L23 of the 2nd lens group, and a negative lens L24.

[0064] Conditions (11) specify the ratio of the synthetic focal distance of the positive lens L23 of the 2nd lens group, and a negative lens L24, and the synthetic focal distance of the whole 2nd lens group. If 1 of an upper limit is exceeded, it will grow [whether mirror frame machine structure becomes complicated and] large, in order do not become high, but the movement magnitude of the 1st lens group becomes large, are easy to enlarge the 2nd lens group scale factor, or dead space tends to be made in the 2nd lens group back in a busy condition, since the principal point of the 2nd lens group becomes image side approach, and for an overall length to become long and to make collapsing thickness thin. Or it cannot do not much thinly. Amendment of astigmatism will become difficult if -0.5 of a lower limit is exceeded.

[0065] In addition, it is more good to make it be the following.

[0066]

(11) ' It is best for -0.4<f2 / f2R<0.7 pan to make it be the following.

[0067]

(11) " About -0.3<f2/f2R<0.4 and the 3rd lens group, although it is good to constitute from all the lens ****** spherical surfaces, it is good in that case to fulfill the following conditions geometrically.

[0068]

(12) R32 is the body side and the radius of curvature which is the field by the side of an image most of the positive lens of the 3rd lens group most as -1.0<(R31+R32)/(R31-R32) <1.2, however R31, respectively.

[0069] If 1.2 of the upper limit of conditions (12) is exceeded, even if fluctuation of the astigmatism by the rear focus becomes large too much and can amend astigmatism good in the infinity object point, astigmatism will tend to get worse to the short-distance object point. Although there is little astigmatism fluctuation by the rear focus when -1.0 of a lower limit is exceeded, the aberration amendment to the infinity object point becomes difficult.

[0070] In addition, it is more good to make it be the following.

[0071]

(12) -- ' -0.3<(R31+R32)/(R31-R32) <1.2 -- it is still better to make it be the following.

[0072]

(12) " Although collapsing thickness was made thin about more than 0.0<(R31+R32)/(R31-R32) <1.0 and the zoom lens section, the means which makes the image formation engine performance good was offered.

[0073] In addition, the zoom lens of this invention is advantageous when electronic image pick-up equipment including a wide angle region is constituted. Half-field angle [of the direction of a vertical angle especially in a wide angle edge] omega W It is desirable to use for the electronic image pick-up equipment with which are satisfied of the following conditions (a wide angle edge half field angle given in each after-mentioned example is equivalent to omegaW.).

[0074] Although an aberration amendment top will become advantageous if a wide angle edge half field angle becomes narrow exceeding 27 degrees of the lower limit of this condition W < 42 degrees of 27 degrees < omega, it is no longer a field angle in a practical wide angle edge. On the other hand, if 42 degrees of a upper limit are exceeded, it will become easy to generate distortion aberration and the chromatic aberration of a scale factor, and lens number of sheets will increase.

[0075] Next, reference is made about the affair which makes filters thin. The infrared-absorption filter which usually has fixed thickness in electronic image pick-up equipment so that infrared light may not carry out incidence to an image pick-up side is inserted in a body side rather than the image sensor. It considers transposing this to thin coating. Although it is the translation which becomes naturally that much thin, there is a secondary effect. Rather than the image sensor in zoom lens system back, to a body side, 80% or more, if the permeability (tau 700) in 700nm introduces 8% or less of near-infrared Sharp

cut coat, permeability (tau 600) with a wavelength of 600nm The permeability of a near infrared region 700nm or more is lower than an absorption type. The permeability by the side of red becomes high relatively, the Magenta-ized inclination by the side of the purple-blue which is the fault of solid state image sensors, such as CCD which has a complementary color mosaic filter, is eased by the gain adjustment, and the color reproduction of the solid state image sensor averages, such as CCD which has a primary color filter, can be obtained.

[0076] Namely, (13) tau600/tau550 >=0.8 (14) It is desirable to fill tau700/tau550 <=0.08. However, tau 550 It is permeability with a wavelength of 550nm.

[0077] In addition, it is more good to make it be the following in both conditions (13) and (14). [both / either or]

[0078] (13) ' tau600/tau550 >=0.85(14)' It is still better for tau700 / tau550 <=0.05 pan to make it be the following in both conditions (13) and (14). [both / either or] It is best to make especially both be the following.

[0079] (13) " tau600/tau550 >=0.9(14)" Another fault of solid state image sensors, such as tau700 / tau550 <=0.03CCD, is that the sensibility to the wavelength of 550nm of a near-ultraviolet region is quite higher than that of human being's eye. This is also highlighting the color blot of the edge section of the image by the chromatic aberration of a near-ultraviolet region. It is fatal if especially optical system is miniaturized. Therefore, the ratio to 550nm it (tau 550) of permeability (tau 400) with a wavelength of 400nm is less than 0.08. If an absorber or a reflector to which the ratio to 550nm it (tau 550) with a permeability (tau 440) of 440nm exceeds 0.4 is inserted on an optical path, a required wavelength region will not be lost on color reproduction (have maintained good color reproduction), but noises, such as a color blot, will be mitigated considerably.

[0080] Namely, (15) tau400/tau550 <=0.08 (16) It is desirable to fill tau440/tau550 >=0.4.

[0081] In addition, it is more good to make it be the following in both conditions (15) and (16). [both / either or]

[0082] (15) ' tau400/tau550 <=0.06(16)' It is still better for tau440 / tau550 >=0.5 pan to make it be the following in both conditions (15) and (16). [both / either or] It is best to make especially both be the following.

[0083] (15) " tau400/tau550 <=0.04(16)" As for tau440/tau550 >=0.6, in addition the installation of these filters, between image formation optical system and image sensors is good.

[0084] On the other hand, in the case of a complementary filter, the merit when using small CCD from the height of the transmitted light energy, since substantial sensibility is high and advantageous also in resolving compared with CCD with a primary color filter is size. Also about the optical low pass filter which is another filter, it is the total thickness tLPF. (mm) is good to fulfill the following conditions.

[0085]

(17) 0.15<tLPF / a< 0.45, however a are the level pixel pitches (unit mum) of an image sensor, and are 5 micrometers or less.

[0086] Although it is also effective to make an optical low pass filter thin in order to make collapsing thickness thin, generally moire depressor effect decreases and is not desirable. On the other hand, the contrast of the frequency component beyond a nyquist limitation decreases, and the phenomenon of moire depressor effect comes to be permitted to some extent by the effect of the diffraction of an image formation lens system as a pixel pitch becomes small. For example, when whenever [azimuth / at the time of projection on the image surface] uses in piles three kinds of filters which have a crystallographic axis in a horizontal (= 0 degree) and the direction of **45 degree, respectively in the direction of an optical axis, it is known that there is moire depressor effect considerably. As a specification to which the filter in this case becomes the thinnest, what can shift only SQRT(1/2) * amum in amum and the direction of **45 degree horizontally, respectively is known. The filter thickness at this time is about set to [1+2*SQRT(1/2)] *a/5.88 (mm). Here, SQRT is the square root and means a square root. This is a specification which makes contrast zero in the frequency which is equivalent to a nyquist limitation exactly. Although the contrast of several % thru/or the frequency equivalent to a nyquist limitation will come out for a while rather than this if it is made thin about dozens of%, ****** stopped under the effect of the above-mentioned diffraction becomes possible.

[0087] Also when carrying out by filter specifications other than the above, for example, a two-sheet pile, and one sheet, it is good to satisfy [include] conditions (17). If 0.45 of the upper limit is exceeded, an optical low pass filter will be too thick, and will become the hindrance of thin-shape-izing. Moire removal will become inadequate if 0.15 of a lower limit is exceeded. However, the conditions of a in the case of carrying this out are 5 micrometers or less.

[0088] If a is 4 micrometers or less, since it is easier to be influenced of diffraction, it is (17)'. It is good also as 0.13<tLPF / a< 0.42.

[0089] Moreover, you may make it be the following according to the number of sheets of a level pixel pitch and the low pass filter to pile up.

[0090] (17) " At 0.3<tLPF / a< 0.4 however a three-sheet pile, and the time of 4<=a<5 (micrometer) At 0.2<tLPF / a< 0.28 however a two-sheet pile, and the time of 4<=a<5 (micrometer) 0.1<tLPF / a< 0.16, however one sheet At and the time of 4<=a<5 (micrometer) It is 0.08<tLPF / a< 0.14, however one sheet at the time of a< 4 (micrometer) at 0.16<tLPF / a< 0.25 however a two-sheet pile, and the time of a< 4 (micrometer) at 0.25<tLPF / a< 0.37 however a three-sheet pile, and the time of a< 4 (micrometer).

[0091] When using an electronic image sensor with a small pixel pitch, image quality deteriorates under the effect of the diffraction effect by narrowing down. It can insert most into which [between the lens sides by the side of a body] optical path. therefore, two or more openings of immobilization of opening size -- having -- one of them -- the 1st lens group -- most -- the lens side by the side of an image, and the 3rd lens group -- And it considers as the electronic image pick-up equipment which can adjust an image surface illuminance by supposing that it is exchangeable with other openings. It is good to perform quantity of light accommodation, as the permeability to 550nm differs in a part of openings in two or more of the openings, respectively and it has a medium which is less than 80%. Or when adjusting so that it may become the quantity of light equivalent to an F value which is set to a (micrometer) / f number <0.4, it is good to consider as the electronic image pick-up equipment which the permeability to 550nm differs in opening, respectively, and has less than 80% of medium. For example, from the open value, if out of range, he has no medium or the permeability to 550nm which is the above-mentioned conditions considers as 91% or more of dummy medium, and it is [like / the diameter of an aperture diaphragm is not made small, so that the effect of diffraction comes out, and / an ND filter] good at the time of within the limits to carry out quantity of light accommodation.

[0092] Moreover, what puts in in opening the optical low pass filter with which a path is made into what was made small in inverse proportion to the F value, two or more of the openings are arranged, respectively, and frequency characteristics differ instead of an ND filter, respectively is sufficient. Since diffraction degradation becomes large as it narrows down, the frequency characteristics of an optical low pass filter are highly set up, so that the diameter of opening becomes small.

[0093]

[Embodiment of the Invention] Hereafter, the examples 1-10 of the zoom lens used for the electronic image pick-up equipment of this invention are explained. The wide angle edge at the time of the infinite distance object point focus of

examples 1-10 (a), an intermediate state (b), and the lens sectional view in a tele edge (c) are shown in drawing 1 - drawing 10 , respectively. I has shown the image surface of CG and CCD for the cover glass of CCD IF and whose low pass filter of G3 and an infrared cut absorption filter G2 and the 3rd lens group are [the 1st lens group / G1 and a diaphragm] LF and an electronic image sensor for S and the 2nd lens group among each drawing. In addition, it may replace with infrared cut absorption filter IF, what was used as the near-infrared Sharp cut coat at the plane of incidence of a transparence plate may be used, and a direct near-infrared Sharp cut coat may be given to a low pass filter LF.
[0094] The 1st lens group G1 of negative refractive power, aperture-diaphragm S, both the convex positive lens, and the cemented lens of both the concave negative lens which are from the positive meniscus lens of a convex on a both concave negative lens and body side as the zoom lens of an example 1 is shown in drawing 1 , It consists of 3rd lens group G3 of the forward refractive power which consists of both convex positive lens, and the 2nd lens group G2 of the forward refractive power which is from the negative meniscus lens of a convex on a body side and both one convex positive lens. In case variable power is carried out to a tele edge from a wide angle edge, the 1st lens group G1 draws the locus of concave, and moves to a body side. Becoming a location by the side of the image surface from a wide angle edge in a tele edge, the 2nd lens group G2 moves to aperture-diaphragm S and one at a body side, and 3rd lens group G3 draws the locus of a convex, and moves to an image surface side, and it becomes a location by the side of a body from a wide angle edge by the tele edge. In order to carry out focusing to the photographic subject of a short distance, it lets out 3rd lens group G3 to a body side.
[0095] The aspheric surface is used for the 3rd page, the field by the side of the image surface of both the concave negative lens of the 1st lens group G1, the field by the side of the body of the cemented lens of the 2nd lens group G2, and the field by the side of the body of both the convex positive lens.
[0096] As the zoom lens of an example 2 is shown in drawing 2 , at a positive meniscus lens [of a convex], and body side to a 1st lens group [of the negative refractive power which consists of both concave negative lens and both convex positive lens] G1, aperture-diaphragm S, and body side The cemented lens of the negative meniscus lens of a convex, In case it consists of 3rd lens group G3 of the forward refractive power which consists of the 2nd lens group G2 of the forward refractive power which consists of both convex positive lens and a **** negative lens, and both one convex positive lens and variable power is carried out to a tele edge from a wide angle edge the 1st lens group G1 -- a body side -- the locus of concave -- drawing -- moving -- a tele edge and a wide angle edge -- abbreviation -- becoming the same location, the 2nd lens group G2 moves to aperture-diaphragm S and one at a body side, and moves 3rd lens group G3 to an image surface side. In order to carry out focusing to the photographic subject of a short distance, it lets out 3rd lens group G3 to a body side.
[0097] The aspheric surface is used for the 3rd page, the field by the side of the image surface of both the concave negative lens of the 1st lens group G1, the field by the side of the body of the cemented lens of the 2nd lens group G2, and the field by the side of the body of both the convex positive lens.
[0098] The 1st lens group G1 of the negative refractive power which is from the positive meniscus lens of a convex on a both concave negative lens and body side as the zoom lens of an example 3 is shown in drawing 3 , aperture-diaphragm S, To a body side at a positive meniscus lens [of a convex], and body side The cemented lens of the negative meniscus lens of a convex, It consists of 3rd lens group G3 of the forward refractive power which consists of both convex positive lens, and the 2nd lens group G2 of the forward refractive power which is from the negative meniscus lens of a convex on a body side and both one convex positive lens. the time of carrying out variable power to a tele edge from a wide angle edge -- the 1st lens group G1 -- a body side -- the locus of concave -- drawing -- moving -- a tele edge and a wide angle edge -- abbreviation -- becoming the same location, the 2nd lens group G2 moves to aperture-diaphragm S and one at a body side, and 3rd lens group G3 is immobilization. In order to carry out focusing to the photographic subject of a short distance, it lets out 3rd lens group G3 to a body side.
[0099] The aspheric surface is used for the 3rd page, the field by the side of the image surface of both the concave negative lens of the 1st lens group G1, the field by the side of the body of the cemented lens of the 2nd lens group G2, and the field by the side of the body of both the convex positive lens.
[0100] As the zoom lens of an example 4 is shown in drawing 4 , to a body side Two negative meniscus lenses of a convex, At a positive meniscus lens [of a convex], and body side to a 1st lens group [of the negative refractive power which consists of both convex positive lens] G1, aperture-diaphragm S, and body side The cemented lens of the negative meniscus lens of a convex, It consists of 3rd lens group G3 of the forward refractive power which consists of both convex positive lens, and the 2nd lens group G2 of the forward refractive power which is from the negative meniscus lens of a convex on a body side and both one convex positive lens. In case variable power is carried out to a tele edge from a wide angle edge, the 1st lens group G1 draws the locus of concave, and moves to a body side. Becoming a location by the side of the image surface from a wide angle edge in a tele edge, the 2nd lens group G2 moves to aperture-diaphragm S and one at a body side, and 3rd lens group G3 draws the locus of a convex, and moves to a body side, and it becomes a location by the side of a body from a wide angle edge by the tele edge. In order to carry out focusing to the photographic subject of a short distance, it lets out 3rd lens group G3 to a body side.
[0101] The aspheric surface is used for the 3rd page, the field by the side of the image surface of the negative meniscus lens by the side of the body of the 1st lens group G1, the field by the side of the body of the cemented lens of the 2nd lens group G2, and the field by the side of the body of both the convex positive lens.
[0102] As the zoom lens of an example 5 is shown in drawing 5 , to a body side The negative meniscus lens of a convex, The 1st lens group G1 of negative refractive power, aperture-diaphragm S, the **** positive lens, and the cemented lens of a **** negative lens which are from the positive meniscus lens of a convex on a body side, In case it consists of 3rd lens group G3 of the forward refractive power which consists of the 2nd lens group G2 of the forward refractive power which consists of both convex positive lens and both concave negative lens, and both one convex positive lens and variable power is carried out to a tele edge from a wide angle edge The locus of concave is drawn and it moves to a body side, and by the tele edge, the 1st lens group G1 becomes a location by the side of the image surface from a wide angle edge, the 2nd lens group G2 moves to aperture-diaphragm S and one at a body side, and 3rd lens group G3 moves it for it to a body side. In order to carry out focusing to the photographic subject of a short distance, it lets out 3rd lens group G3 to a body side.
[0103] The aspheric surface is used for the 3rd page, the field by the side of the image surface of the negative meniscus lens of the 1st lens group G1, the field by the side of the body of the cemented lens of the 2nd lens group G2, and the field by the side of the body of both the convex positive lens.
[0104] The 1st lens group G1 of negative refractive power, aperture-diaphragm S, both the convex positive lens, and the cemented lens of both the concave negative lens which are from the positive meniscus lens of a convex on a both concave negative lens and body side as the zoom lens of an example 6 is shown in drawing 6 , In case it consists of 3rd lens group G3 of the forward refractive power which consists of the 2nd lens group G2 of the forward refractive power which consists of

both convex positive lens and both concave negative lens, and both one convex positive lens and variable power is carried out to a tele edge from a wide angle edge The 1st lens group G1 draws the locus of concave on a body side, and it moves, and becomes a location by the side of the image surface from a wide angle edge in a tele edge, the 2nd lens group G2 moves to aperture-diaphragm S and one at a body side, 3rd lens group G3 draws the locus of a convex on a body side, and it moves, and becomes a location by the side of the image surface from a wide angle edge in a tele edge. In order to carry out focusing to the photographic subject of a short distance, it lets out 3rd lens group G3 to a body side.

[0105] The aspheric surface is used for the 3rd page, the field by the side of the image surface of both the concave negative lens of the 1st lens group G1, the field by the side of the body of the cemented lens of the 2nd lens group G2, and the field by the side of the body of both the convex positive lens.

[0106] The 1st lens group G1 of negative refractive power, aperture-diaphragm S, both the convex positive lens, and the cemented lens of both the concave negative lens which are from the positive meniscus lens of a convex on a both concave negative lens and body side as the zoom lens of an example 7 is shown in drawing 7 , In case it consists of 3rd lens group G3 of the forward refractive power which consists of the 2nd lens group G2 of the forward refractive power which consists of both convex positive lens and both concave negative lens, and both one convex positive lens and variable power is carried out to a tele edge from a wide angle edge The 1st lens group G1 draws the locus of concave on a body side, and it moves, and becomes a location by the side of a body from a wide angle edge in a tele edge, the 2nd lens group G2 moves to aperture-diaphragm S and one at a body side, 3rd lens group G3 draws the locus of a convex on a body side, and it moves, and becomes the location same at a tele edge and wide angle edge. In order to carry out focusing to the photographic subject of a short distance, it lets out 3rd lens group G3 to a body side.

[0107] The aspheric surface is used for the 3rd page, the field by the side of the image surface of both the concave negative lens of the 1st lens group G1, the field by the side of the body of the cemented lens of the 2nd lens group G2, and the field by the side of the body of both the convex positive lens.

[0108] The 1st lens group G1 of the negative refractive power which is from the positive meniscus lens of a convex on a both concave negative lens and body side as the zoom lens of an example 8 is shown in drawing 8 , aperture-diaphragm S, To a body side at a positive meniscus lens [of a convex], and body side The cemented lens of the negative meniscus lens of a convex, It consists of 3rd lens group G3 of the forward refractive power which consists of both convex positive lens, and the 2nd lens group G2 of the forward refractive power which is from the negative meniscus lens of a convex on an image surface side and both one convex positive lens. In case variable power is carried out to a tele edge from a wide angle edge, the 1st lens group G1 draws the locus of concave, and moves to a body side. Becoming a location by the side of a body from a wide angle edge in a tele edge, the 2nd lens group G2 moves to aperture-diaphragm S and one at a body side, and 3rd lens group G3 draws the locus of a convex, and moves to an image surface side, and it becomes a location by the side of the image surface from a wide angle edge by the tele edge. In order to carry out focusing to the photographic subject of a short distance, it lets out 3rd lens group G3 to a body side.

[0109] The aspheric surface is used for the 3rd page, the field by the side of the image surface of both the concave negative lens of the 1st lens group G1, the field by the side of the body of the cemented lens of the 2nd lens group G2, and the field by the side of the body of both the convex positive lens.

[0110] As the zoom lens of an example 9 is shown in drawing 9 , to a body side The negative meniscus lens of a convex, The 1st lens group G1 of negative refractive power, aperture-diaphragm S, the **** positive lens, and the cemented lens of a **** negative lens which are from the positive meniscus lens of a convex on a body side, It consists of 3rd lens group G3 of the forward refractive power which consists of both convex positive lens, and the 2nd lens group G2 of the forward refractive power which is from the negative meniscus lens of a convex on a body side and both one convex positive lens. In case variable power is carried out to a tele edge from a wide angle edge, the 1st lens group G1 draws the locus of concave on a body side, and it moves, and becomes a location by the side of the image surface from a wide angle edge in a tele edge, the 2nd lens group G2 moves to aperture-diaphragm S and one at a body side, and 3rd lens group G3 moves to a body side. In order to carry out focusing to the photographic subject of a short distance, it lets out 3rd lens group G3 to a body side.

[0111] The aspheric surface is used for the 3rd page of the fields by the side of the field by the side of the image surface of the negative meniscus lens of the 1st lens group G1, the field by the side of the body of the cemented lens of the 2nd lens group G2, and the image surface of both the convex positive lens.

[0112] As the zoom lens of an example 10 is shown in drawing 10 , to a body side The negative meniscus lens of a convex, At a positive meniscus lens [of a convex], and body side to a 1st lens group [of the negative refractive power which is from the positive meniscus lens of a convex on a body side] G1, aperture-diaphragm S, and body side The cemented lens of the negative meniscus lens of a convex, It is from 3rd lens group G3 of the forward refractive power which consists of a positive meniscus lens of a convex, and the 2nd lens group G2 of the forward refractive power which becomes from the negative meniscus lens of a convex at an image surface side and both one convex positive lens on an image surface side. In case variable power is carried out to a tele edge from a wide angle edge, the 1st lens group G1 draws the locus of concave, and moves to a body side. Becoming a location by the side of the image surface from a wide angle edge in a tele edge, the 2nd lens group G2 moves to aperture-diaphragm S and one at a body side, and 3rd lens group G3 draws the locus of a convex, and moves to a body side, and it becomes a location by the side of a body from a wide angle edge by the tele edge. In order to carry out focusing to the photographic subject of a short distance, it lets out 3rd lens group G3 to a body side.

[0113] The aspheric surface is used for the 3rd page of the fields by the side of the field by the side of the image surface of the negative meniscus lens of the 1st lens group G1, the field by the side of the body of the cemented lens of the 2nd lens group G2, and the image surface of an independent positive meniscus lens.

[0114] Although the numeric data of each above-mentioned example is shown below In a notation, f outside the above a half-field angle and FNO for a whole system focal distance and omega The f number, For a wide angle edge and ST, an intermediate state and TE are [WE] a tele edge, r1, and r2. -- is the radius of curvature of each lens side, d1, and d2. -- is [the refractive index of d line of each lens, nud1, and nud2 -- of spacing between each lens side, nd1, and nd2 --] the Abbe numbers of each lens. In addition, an aspheric surface configuration uses x as the optical axis which made the travelling direction of light forward, and when y is taken in the direction which intersects perpendicularly with an optical axis, it is expressed with the following formula.

[0115] For 1+{1-(K+1) (y/r) 2} 1 / x= (y2 / r) / [2]+A4y4+A6y6+A8y8+A10y10, however r, paraxial radius of curvature and K are a constant of the cone, A4, and A6, A8 and A10. It is the 4th aspheric surface multiplier [6th / 8th / 10th], respectively.

[0116]

Example 1r1 = -102.7129 d1 = 0.7000 nd 1 = 1.80610 nud1 =40.92 r2 = 5.3602 (aspheric surface) d2 = 2.0000 r3 = 11.4378 d3 = 1.8000 nd 2 = 1.84666 nud2 =23.78 r4 = 98.3090 d4 = (adjustable) r5 = infinity (diaphragm) d5 = 1.2000 r6 = 4.9724(aspheric surface) d6 = 2.0000nd 3 = 1.80610 nud3 =40.92 r7 = -64.0363 d7 = 0.7000 nd 4 = 1.84666 nud4 =23.78 r8 = 7.0009 d8 =

1.1549 r9 = 15.2680 (aspheric surface) d9 = 1.3000 nd 5 = 1.69350 nud5 =53.21 r10=-12.7034 d10= 0.1500 r11= 91.7989 d11= 0.7000 nd 6 = 1.80100 nud6 =34.97 r12= 8.2347 d12= (adjustable) r13= 11.7154 d13=1.8000 nd 7 = 1.48749 nud7 =70.23 r14=-20.5935 d14= (adjustable) r15= infinity d15= 0.8000 nd 8 = 1.51633 nud8 =64.14 r16= infinity d16= 1.5000 nd 9 = 1.54771 nud9 =62.84 r17= infinity d17= 0.8000 r18= infinity d18= 0.7500nd 10= 1.51633 nud10=64.14 r19= infinity d19= 1.2097r20= infinity (image surface) The 2nd page of aspheric surface multiplier K = 0 A4 =-9.1908 x10-4 A6 = 1.0097x10-5A8 =-1.5014 x10-6A10= 0.0000 6th page K = 0 A4 =-1.4735 x10-4 A6 = 1.6281 x10-5 A8 =-7.9774 x10-7 A10= 0.0000 The 9th page K = 0 A4 =-2.0216 x10-3 A6 =-1.8880 x10-4A8 = 9.7090 x10-6 A10= 0.0000 Zoom data (infinity)
WE ST TEf (mm) 4.50523 8.68872 12.89933 FNO 2.6065 3.5812 4.3925omega (degree) 33.2 18.1 12.4d4 15.98285 5.88144 1.50000d12 2.53628 8.66957 13.53479 d14 0.921730.42989 0.99810.
[0117]
Example 2r1 = -40.0207 d1 = 0.7000 nd 1 = 1.80610 nud1 =40.92 r2 = 4.8393 (aspheric surface) d2 = 2.7104 r3 = 14.6390 d3 = 1.5606 nd 2 = 1.84666 nud2 =23.78 r4 = -100.9877 d4 = (adjustable) r5 = infinity (diaphragm) d5 = 1.2000 r6 = 4.5526(aspheric surface) d6 = 1.8758nd 3 = 1.80610 nud3 =40.92 r7 = 15.8025 d7 = 0.9429 nd 4 = 1.84666 nud4 =23.78 r8 = 4.0750 d8 = 0.6028 r9 = 7.1659 (aspheric surface) d9 = 1.8221 nd 5 = 1.69350 nud5 =53.21 r10=-8.0623 d10= 0.1000 r11= infinity d11= 1.0000 nd 6 = 1.80100 nud6 =34.97 r12= 6.7380 d12= (adjustable) r13= 13.4670 d13= 1.6540 nd 7 = 1.48749 nud7 =70.23 r14= -21.9112 d14= (adjustable) r15= infinity d15= 0.8000 nd 8 = 1.51633 nud8 =64.14 r16= infinity d16= 1.5000 nd 9 = 1.54771 nud9=62.84 r17= infinity d17= 0.8000 r18= infinity d18= 0.7500 nd 10= 1.51633 nud10=64.14 r19= infinityd19= 1.2000 r20= infinity (image surface) Aspheric surface multiplier The 2nd page K = 0 A4 =-1.6364 x10-3 A6 = 1.1356 x10-5 A8=-2.5627 x10-6 A10= 0.0000 6th page K = 0 A4 = -3.9899x10-4 A6 = -2.2843x10-5 A8 = -1.2585x10-6 A10= -9.0236x10-9 The 9th page K = 0 A4 =-1.7288 x10-3 A6 = 4.6545 x10-5 A8 =-3.7671 x10-6 A10= 3.6071 x10-7 zoom data (infinity)
WE ST TEf (mm) 4.20000 8.59999 12.80032 FNO 2.4980 3.5636 4.6676omega (degree) 35.2 18.3 12.4d4 14.39292 4.31686 1.50000d12 1.90425 8.66884 15.45557 d14 1.560491.52138 0.90000.
[0118]
Example 3r1 = -41.7871 d1 = 0.7000 nd 1 = 1.80610 nud1 =40.92 r2 = 4.8061 (aspheric surface) d2 = 2.1538 r3 = 11.7830 d3 = 1.5885 nd 2 = 1.84666 nud2 =23.78 r4 = 498.8711 d4 = (adjustable) r5 = infinity (diaphragm) d5 = 1.2000 r6 = 4.4711(aspheric surface) d6 = 1.8148nd 3 = 1.80610 nud3 =40.92 r7 = 16.1235 d7 = 0.8513 nd 4 = 1.84666 nud4 =23.78 r8 = 4.0848 d8 = 0.5201 r9 = 6.1325 (aspheric surface) d9 = 1.6063 nd 5 = 1.69350 nud5 =53.21 r10=-11.1687 d10= 0.1000 r11= 16.3851 d11= 1.0000 nd 6 = 1.80100 nud6 =34.97 r12= 4.8782 d12= (adjustable) r13= 17.5725 d13=1.7579 nd 7 = 1.48749 nud7 =70.23 r14=-13.0293 d14= 0.9000 r15= infinity d15= 0.8000 nd 8 = 1.51633 nud8 =64.14 r16= infinity d16= 1.5000 nd 9 = 1.54771 nud9 =62.84 r17= infinity d17= 0.8000 r18= infinity d18= 0.7500 nd 10= 1.51633 nud10=64.14 r19= infinity d19= 1.2001 r20= infinity (image surface) Aspheric surface multiplier The 2nd page K = 0 A4 =-1.5240x10-3 A6 = 7.1028 x10-6 A8 =-2.5635 x10-6 A10= 0.0000 6th page K = 0 A4 =-4.1354 x10-4A6 =-2.4486 x10-5 A8 =-1.4312 x10-6 A10= 3.7941 x10-8 The 9th page K = 0 A4 =-1.7166 x10-3 A6 = 5.3328 x10-5 A8 =-4.9514 x10-6 A10=-5.3554 x10-8 zoom data (infinity)
WE ST TEf (mm) 4.20005 8.60008 12.80003 FNO </SUB> 2.6418 3.7743 4.8647omega (degree) 35.2 18.3 12.5d4 13.62386 4.39163 1.50000 d12 2.13358 8.33646 14.25744 .
[0119]
Example 4r1 = 27.0909 d1 = 0.7000 nd 1 = 1.80610 nud1 =40.92 r2 = 6.6293 (aspheric surface) d2 = 1.8000 r3 = 144.3405 d3 = 0.7000 nd 2 = 1.80100 nud2 =34.97 r4 = 8.3285 d4 = 0.8000 r5 = 9.3403 d5 = 1.8000 nd 3 = 1.80518 nud3 =25.42r6 = -172.3059 d6 = (adjustable) r7 = infinity(diaphragm) d7 = 1.2000 r8 = 4.6685 (aspheric surface) d8 = 2.0000 nd 4= 1.80610 nud4 =40.92 r9 = 39.3390 d9 = 0.7000nd5 =1.84666nud5 =23.78 r10= 6.3668 d10= 1.0180r11= 21.8104 (aspheric surface) d11= 1.3000 nd 6 = 1.69350 nud6=53.21 r12=-13.5364 d12= 0.1500 r13= 38.5671 d13= 0.7000 nd 7 = 1.80518 nud7 =25.42 r14= 8.0481 d14= (adjustable) r15= 9.5072 d15= 1.8000 nd 8 = 1.48749 nud8 =70.23 r16= -24.4883 d16= (adjustable) r17= infinity d17= 0.8000nd 9 = 1.51633 nud9 =64.14 r18= infinity d18= 1.5000 nd 10= 1.54771 nud10=62.84 r19=infinity d19= 0.8000r20= infinity d20= 0.7500nd11=1.51633nud11=64.14 r21= infinity d21= 1.2108 r22= infinity (image surface) aspheric surface multiplier The 2nd page K = 0 A4 =-2.9630 x10-4 A6 = 4.2847 x10-6 A8 =-3.6003 x10-7A10= 0.0000 8th page K = 0 A4 =-2.6881 x10-4 A6 = 2.5560 x10-5A8 =-3.5822x10-7 A10= 0.0000 The 11th page K = 0 A4 =-2.1333 x10-3 A6 =-2.4378 x10-4 A8 = 3.2564 x10-7 A10= 0.0000 Zoom data (infinity)
WE ST TEf (mm) 4.48846 8.69183 12.90297 FNO 2.5989 3.4016 4.5450omega (degree) 33.4 18.4 12.5d6 14.80359 3.81650 1.50000d14 2.53628 7.33575 14.91963 d16 0.921731.86494 0.99412.
[0120]
Example 5r1 = 208.2759 d1 = 0.7000 nd 1 = 1.74320 nud1 =49.34 r2 = 4.6930 (aspheric surface) d2 = 2.0000 r3 = 8.5950 d3 = 1.8000 nd 2 = 1.80518 nud2 =25.42 r4 = 20.6048 d4 = (adjustable) r5 = infinity (diaphragm) d5 = 1.2000 r6 = 4.2440(aspheric surface) d6 = 2.0000nd 3 = 1.80610 nud3 =40.92 r7 = infinity d7 = 0.7000 nd 4 = 1.84666 nud4 =23.78r8 = 5.0693d8 = 0.6000r9 = 24.7066 (aspheric surface) d9 = 1.3000 nd 5 = 1.69350 nud5 =53.21 r10=-10.1759 d10= 0.1500 r11=-266.8373 d11= 0.7000 nd 6 = 1.80100 nud6 =34.97 r12= 14.0737 d12= (adjustable) r13=20.4220 d13= 1.8000 nd 7 = 1.48749 nud7 =70.23 r14= -14.3628 d14= (adjustable) r15= infinity d15= 0.8000nd 8 = 1.51633 nud8 =64.14 r16= infinityd16= 1.5000 nd 9 = 1.54771 nud9 =62.84 r17= infinity d17= 0.8000 r18= infinity d18= 0.7500 nd 10= 1.51633 nud10=64.14 r19= infinity d19= 1.2092r20= infinity (image surface) The 2nd page of aspheric surface multiplier K = 0 A4 =-1.1214 x10-3 A6 = 3.1893 x10-5 A8 =-4.1833 x10-6 A10= 0.0000 6th page K = 0 A4 =-1.7255 x10-5 A6 =-4.4178 x10-5 A8 =9.1087 x10-6 A10= 0.0000 The 9th page K = 0 A4 =-3.5926x10-3 A6 =-7.1592 x10-5 A8 =-6.8024 x10-5 A10= 0.0000 Zoom data (infinity)
WE ST TEf (mm) 4.52199 8.69159 12.89618 FNO 2.6728 3.5913 4.5324omega (degree) 33.2 18.1 12.4d4 13.53589 4.62823 1.50000d12 2.53628 7.65616 12.90171 d14 0.921730.98067 1.00178.
[0121]
Example 6r1 = -115.4675 d1 = 0.7000 nd 1 = 1.80610 nud1 =40.92 r2 = 5.0884 (aspheric surface) d2 = 2.4077 r3 = 11.8048 d3 = 1.5055 nd 2 = 1.84666 nud2 =23.78 r4 = 79.1966 d4 = (adjustable) r5 = infinity (diaphragm) d5 = 1.2000 r6 = 4.9875(aspheric surface) d6 = 2.2097nd 3 = 1.80610 nud3 =40.92 r7 = -92.9504 d7 = 0.7000 nd 4 = 1.84666 nud4 =23.78 r8 = 7.0480 d8 = 1.7157 r9 = 20.4501 (aspheric surface) d9 = 1.4488 nd 5 = 1.69350 nud5 =53.21 r10=-5.4179 d10= 0.2153 r11= -6.0014 d11= 1.0000 nd 6 = 1.80100 nud6 =34.97 r12= 56.3492 d12= (adjustable) r13= 12.4691 d13=1.6359 nd 7 = 1.48749 nud7 =70.23 r14=-24.0279 d14= (adjustable) r15= infinity d15= 0.8000 nd 8 = 1.51633 nud8 =64.14 r16= infinity d16= 1.5000 nd 9 = 1.54771 nud9 =62.84 r17= infinity d17= 0.8000 r18= infinity d18= 0.7500nd 10= 1.51633 nud10=64.14 r19= infinity d19= 1.1985r20= infinity (image surface) The 2nd page of aspheric surface multiplier K = 0 A4 =-1.0638 x10-3 A6 = 2.1512x10-6A8 =-1.6979 x10-6A10= 0.0000 6th page K = 0 A4 =-2.6779 x10-4 A6 = 1.4102 x10-6 A8 =-8.0728 x10-7 A10= 0.0000 The 9th page K = 0 A4 =-2.1523 x10-3 A6 =-8.1365 x10-5A8 =-5.0480 x10-6 A10= 0.0000 Zoom data (infinity)
WE ST TEf (mm) 4.49939 8.59837 12.79887 FNO 2.6057 3.4199 4.4288omega (degree) 33.2 18.4 12.5d4 14.90728 4.50456 1.50000d12 2.34564 7.26336 13.74810 d14 0.958501.50353 0.90000.
[0122]

Example 7r1 = -552.0327 d1 = 0.7000 nd 1 = 1.80610 nud1 =40.92 r2 = 4.3477 (aspheric surface) d2 = 1.6776 r3 = 8.2917 d3 = 1.5233 nd 2 = 1.84666 nud2 =23.78 r4 = 25.4637 d4 = (adjustable) r5 = infinity (diaphragm) d5 = 1.2000 r6 = 4.7104(aspheric surface) d6 = 1.9721nd3 = 1.80610 nud3 =40.92 r7 = -33.7287 d7 = 0.7000 nd 4 = 1.84666 nud4 =23.78r8 = 7.9668d8 = 1.9478r9 = 22.3098 (aspheric surface) d9 = 1.3699 nd 5 = 1.69350 nud5 =53.21 r10=-5.5074 d10= 0.1000 r11=-6.0325 d11= 1.0000 nd 6 = 1.80100 nud6 =34.97 r12= 52.7538 d12= r(adjustable)13= 15.2026 d13= 1.7414 nd 7 = 1.48749 nud7 =70.23 r14= -14.4840 d14= (adjustable) r15= infinity d15= 0.8000 nd 8 = 1.51633 nud8 =64.14 r16= infinity d16= 1.5000 nd 9 = 1.54771 nud9 =62.84 r17= infinity d17= 0.8000 r18= infinity d18= 0.7500 nd 10= 1.51633 nud10=64.14 r19= infinity d19= 1.2000 r20= infinity (image surface) Aspheric surface multiplier The 2nd page K = 0 A4 =-1.4967x10-3 A6 = 1.2766 x10-5 A8 =-5.5780 x10-6 A10= 0.0000 The 6th page K = 0 A4 =-3.4707 x10-4 A6 = 2.7502 x10-6 A8 =-8.5549 x10-7 A10= 0.0000 The 9th page K = 0 A4 =-2.6615 x10-3 A6 =-9.6885 x10-5 A8 =-1.1909 x10-5 A10= 0.0000 Zoom data (infinity)
WE ST TEf (mm) 4.50002 8.89986 12.79811 FNO 2.6022 3.5568 4.6259omega (degree) 33.1 17.8 12.6d4 10.91791 3.18224 1.50000d12 1.70000 7.41371 14.11791 d14 0.900001.65812 0.90000.

[0123]
Example 8r1 = -34.8037 d1 = 0.7000 nd 1 = 1.80610 nud1 =40.92 r2 = 4.1900 (aspheric surface) d2 = 1.1999 r3 = 8.0659 d3 = 1.6447 nd 2 = 1.84666 nud2 =23.78 r4 = 48.7210 d4 = (adjustable) r5 = infinity (diaphragm) d5 = 1.2000 r6 = 3.8631(aspheric surface) d6 = 1.7680nd3 = 1.80610 nud3 =40.92 r7 = 62.8242 d7 = 0.7000 nd 4 = 1.84666 nud4 =23.78r8 = 4.5969d8 = 2.3429r9 = 13.0143 (aspheric surface) d9 = 1.4756 nd 5 = 1.69350 nud5 =53.21 r10=-7.3240 d10= 0.1000 r11=-6.0586 d11= 1.0000 nd 6 = 1.80100 nud6 =34.97 r12= -25.9560 d12= r(adjustable)13= 44.0311 d13= 1.6462 nd 7 = 1.48749 nud7 =70.23 r14= -10.9953 d14= (adjustable) r15= infinity d15= 0.8000 nd 8 = 1.51633 nud8 =64.14 r16= infinity d16= 1.5000 nd 9 = 1.54771 nud9 =62.84 r17= infinity d17= 0.8000 r18= infinity d18= 0.7500 nd 10= 1.51633 nud10=64.14 r19= infinity d19= 1.1968 r20= infinity (image surface) Aspheric surface multiplier The 2nd page K = 0 A4 =-2.0325x10-3 A6 =-5.3892 x10-6 A8 =-6.1267 x10-6 A10= 0.0000 The 6th page K = 0 A4 =-7.6210 x10-4 A6 =-2.6462 x10-5 A8 =-4.0575 x10-6 A10=-1.4214 x10-8 The 9th page K= 0 A4 =-1.9457 x10-3 A6 =-9.6412 x10-5 A8 = 9.3922 x10-7 A10=-3.1543 x10-6 zoom data (infinity)
WE ST TEf (mm) 4.49848 8.59759 12.79866 FNO 2.6659 3.7467 4.6171omega (degree) 33.2 18.5 12.7d4 10.65871 4.48879 1.50000d12 1.89640 8.96466 14.27271 d14 1.117600.02771 0.90000.

[0124]
Example 9r1 = 354.9584 d1 = 0.7000 nd 1 = 1.80610 nud1 =40.92 r2 = 4.6698 (aspheric surface) d2 = 2.0000 r3 = 9.2747 d3 = 1.8000 nd 2 = 1.84666 nud2 =23.78 r4 = 29.2897 d4 = (adjustable) r5 = infinity (diaphragm) d5 = 1.2000 r6 = 4.7808(aspheric surface) d6 = 2.0000nd3 = 1.80610 nud3 =40.92 r7 = -100.0000 d7 = 0.7000 nd 4 = 1.84666 nud4 =23.78r8 = 7.1229d8 = 0.9250r9 = 11.1248 d9 = 1.3000 nd5 =1.69350nud5 =53.21 r10= -575.7637 (aspheric surface) d10= 0.1500 r11= 149.0119 d11= 0.7000 nd 6 = 1.84666 nud6 =23.78 r12= 16.0252 d12= (adjustable) r13= 18.2359 d13= 1.8000 nd 7 = 1.48749 nud7 =70.23 r14=-16.5835 d14= (adjustable) r15= infinity d15= 0.8000 nd 8 = 1.51633 nud8 =64.14 r16= infinity d16= 1.5000 nd 9 = 1.54771 nud9 =62.84 r17= infinity d17= 0.8000 r18= infinity d18= 0.7500nd 10= 1.51633 nud10=64.14 r19= infinity d19= 1.2099 r20= infinity (image surface) aspheric surface multiplier The 2nd page K= 0 A4 =-1.1690 x10-3 A6 = 1.7413 x10-5 A8 =-3.7161 x10-6A10= 0.0000 6th page K = 0 A4 =-8.5856x10-5A6 = 1.6399 x10-6 A8 =-4.4906 x10-8 A10= 0.0000 The 10th page K = 0 A4 = 3.0886 x10-3 A6 = 7.0935 x10-5 A8 = 2.3661 x10-5 A10= 0.0000 Zoom data (infinity)
WE ST TEf (mm) 4.50424 8.68935 12.89934 FNO 2.6359 3.5740 4.5352omega (degree) 33.3 18.1 12.4d4 13.20936 4.52377 1.50000d12 2.53628 7.86108 13.31534 d14 0.921730.98683 0.99884.

[0125]
Example 10r1 = 84.8334 d1 = 0.7000 nd 1 = 1.74320 nud1 =49.34 r2 = 4.8594 (aspheric surface) d2 = 2.0000 r3 = 9.0964 d3 = 1.8000 nd 2 = 1.84666 nud2 =23.78 r4 = 18.5606 d4 = (adjustable) r5 = infinity (diaphragm) d5 = 1.2000 r6 = 4.2563(aspheric surface) d6 = 2.0000nd3 = 1.80610 nud3 =40.92 r7 = 100.0000 d7 = 0.7000 nd 4 = 1.84666 nud4 =23.78r8 = 6.3678d8 = 0.4000r9 = -34.3924 d9 = 1.3000 nd5 =1.69350nud5 =53.21 r10= -8.0179 (aspheric surface) d10= 0.3000 r11= -8.3805 d11= 0.7000 nd 6 = 1.84666 nud6 =23.78 r12= -21.0856 d12= (adjustable) r13= 14.6488 d13= 1.8000 nd 7 = 1.48749 nud7 =70.23 r14=-20.2077 d14= (adjustable) r15= infinity d15= 0.8000 nd 8 = 1.51633 nud8 =64.14 r16= infinity d16= 1.5000 nd 9 = 1.54771 nud9 =62.84 r17= infinity d17= 0.8000 r18= infinity d18= 0.7500nd 10= 1.51633 nud10=64.14 r19= infinity d19= 1.2068 r20= infinity (image surface) aspheric surface multiplier The 2nd page K= 0 A4 =-1.0284 x10-3 A6 = 3.3497 x10-5 A8 =-3.4598 x10-6A10= 0.0000 6th page K = 0 A4 =-5.8749x10-5A6 =-9.9305 x10-6 A8 =6.6151 x10-6 A10= 0.0000 The 10th page K = 0 A4 = 3.5852 x10-3 A6 = 2.6012 x10-4 A8 = 4.5257 x10-5 A10= 0.0000 Zoom data (infinity)
WE ST TEf (mm) 4.51247 8.69085 12.90169 FNO 2.7040 3.5173 4.5477omega (degree) 33.2 18.1 12.3d4 13.56120 4.06037 1.50000d12 2.53628 6.76140 13.02411 d14 0.921731.69971 1.00981.

[0126] The aberration Fig. at the time of the infinite distance object point focus of the above example 1, and photographic subject distance the focus of 10cm is shown in drawing 11 and drawing 12 , respectively. In these aberration Figs., (a) shows the spherical aberration [in / a wide angle edge and (b), and / in (c) / a tele edge] SA, Astigmatism AS, the distortion aberration DT, and the chromatic aberration of magnification CC. [an intermediate state] "FIY" expresses image quantity among drawing.

[0127] In addition, the criteria of the amount of deflections of the field and the becoming radius of curvature r of the criteria spherical surface are shown as ra of the field (a is a field number) about the aspheric surface indicated in the above-mentioned example.

[0128] Next, Asp21F about the value of condition (1) - (5) and (7) - in each above-mentioned example (17), and conditions (6) and Asp2R And the value of L is shown.

Example 1 2 3 4 5 (1) 1.40795 0.89509 0.91360 1.36378 1.19446 (2) 0.50176 0.69462 0.84327 0.55884 0.52936 (3) 0.02679 0.01786 0.01786 0.02679 0.02679 (4) 0.10067 0.45293 0.48599 0.05301 0.21846 (5) 35.38000 35.3800035.38000 44.93000 35.38000 (7) -0.16942 0.05535 0.04515 -0.15390 -0.08862 (8) 0.28050 1.40535 1.35749 0.135340.68642 (9) 0.20624 0.10763 0.09287 0.18179 0.10714 (10) -0.22380 2.21234 2.06386 0.34032 0.00000 (11) 0.20618 0.91029 0.89705 0.10983 0.39782 (12) -0.27479 -0.23868 0.14846-0.44068 0.17419 (13) 1.0 1.0 1.0 1.0 1.0 (14) 0.04 0.04 0.04 0.04 0.04 (15) 0.0 0.0 0.0 0.0 0.0 (16) 1.06 1.06 1.06 1.06 1.06 (17) 0.333 0.333 0.333 0.333 0.333 (a= 3.0) (a= 3.0) (a= 3.0) (a= 3.0) (a= 3.0) Asp21F -0.00086 -0.00377 -0.00393 -0.00055 -0.00159 Asp2R -0.01973 -0.01290-0.01280 -0.03454 -0.02245L 5.6 5.6 5.6 5.6 5.6 .

Example 6 7 8 9 10 (1) 1.4130 1.6913 1.1900 1.48990 1.49609 (2) 0.10050 0.08851 -0.02852 0.04735 0.03011 (3) 0.03845 0.01786 0.01786 0.02679 0.05357 (4) 0.11252 0.06773 0.26914 0.11434 0.04250 (5) 35.38000 35.38000 35.38000 46.57000 46.57000 (7) -0.17120 -0.25687 -0.08674 -0.19676 -0.19874 (8) 0.34339 0.18764 0.87599 0.370050.13448 (9) 0.30638 0.34782 0.41838 0.16517 0.07143 (10) -0.14892 -0.32727 0.20611 -0.12627 0.10616 (11) 0.22705 0.11962 0.46776 0.20849 0.07773 (12) -0.31671 0.02420 0.60036 0.04746 -0.15948 (13) 1.0 1.0 1.0 1.0 1.0 (14) 0.04 0.04 0.04 0.04 0.04 (15) 0.0 0.0 0.0 0.0 0.0 (16) 1.06 1.06 1.06 1.06 1.06 (17) 0.333 0.333 0.333 0.3330.333 (a= 3.0) (a= 3.0) (a= 3.0) (a= 3.0) (a= 3.0) Asp21F -0.00215 -0.00276-0.00693 -0.00065 -0.00027Asp2R -0.01929-0.02414-0.01817 0.02770 0.03728 L 5.6 5.6 5.6 5.6 5.6 .

[0129] In addition, total thickness tLPF of the low pass filter LF of examples 1-10 The three-sheet pile constitutes each

from 1.500 (mm). Of course, an above-mentioned example can be variously changed within the limits of configurations of having described above, such as constituting for example, the low pass filter LF from one sheet.
[0130] Here, the diagonal length L and the pixel spacing a of an effective image pick-up side are explained. Drawing 14 is drawing showing one example of the pixel array of an image sensor, and the pixel (drawing 14) of the pixel of R (red), G (green), and B (blue) or cyanogen, MAZENDA, yellow, and four colors of Green (green) is allotted in the shape of a mosaic at intervals of [a] the pixel. An effective image pick-up side means the field within the photo-electric-conversion side on the image sensor used for playbacks (the display on a personal computer, printing by the printer, etc.) of the photoed image. The effective image pick-up side shown all over drawing is set as the field narrower than all the photo-electric-conversion sides of an image sensor to compensate for the engine performance (image circle which the engine performance of optical system can secure) of optical system. The diagonal length L of an effective image pick-up side is diagonal length of this effective image pick-up side. In addition, although it is good as modification being possible in various image pick-up range used for playback of an image, in case the zoom lens of this invention is used for the image pick-up equipment which has such a function, the diagonal length L of the effective image pick-up side changes. In such a case, the diagonal length L of the effective image pick-up side in this invention is taken as the maximum in the range which L can take.
[0131] Moreover, about an infrared cut means, there are infrared cut absorption filter IF and an infrared Sharp cut coat, and an infrared Sharp cut coat is not absorption but the cut by reflection in the case where an infrared-absorption object contains infrared cut absorption filter IF in glass. therefore -- said -- as carried out, this infrared cut absorption filter IF may be removed, a direct infrared Sharp cut coat may be given to a low pass filter LF, and you may give on dummy transparence monotonous.
[0132] As for the near-infrared Sharp cut coat in this case, it is desirable for permeability with a wavelength of 600nm to constitute 80% or more, so that permeability with a wavelength of 700nm may become 10% or less. Specifically, they are the multilayers which consist of the following lamination of 27 layers. However, design wavelength is 780nm.
[0133]
Radical Plate The quality of the material Physical thickness (nm) lambda/4 -------------------------------- The 1st layer aluminum 2O3 58.96 0.50 The 2nd layer TiO2 84.19 1.00 The 3rd layer SiO2 134.14 1.00 The 4th layer TiO2 84.19 1.00 The 5th layer SiO2 134.14 1.00 The 6th layer TiO2 84.19 The 1.00 7th layer SiO2 134.141.00 The 8th layer TiO2 84.19 1.00 The 9th layer SiO2 134.14 The 1.00 10th layer TiO2 84.19 1.00 The 11th layer SiO2 134.141.00 The 12th layer TiO2 84.19 1.00 The 13th layer SiO2 134.14 1.00 The 14th layer TiO2 84.19 1.00 The 15th layer SiO2 178.41 1.33 The 16th layer TiO2 101.03 1.21 The 17th layer SiO2 167.67 1.25 The 18th layer TiO2 96.821.15 The 19th layer SiO2 147.55 1.05 The 20th layer TiO2 84.19 1.00 The 21st layer SiO2 160.97 1.20 The 22nd layer TiO2 84.19 1.00 The 23rd layer SiO2 154.26 1.15 The 24th layer TiO2 95.13 1.13 The 25th layer SiO2 160.97 1.20 The 26th layer TiO2 99.34 1.18 The 27th layer SiO2 87.19 0.65 ------------------- ------------ sky Mind .
[0134] The permeability property of the above-mentioned near-infrared Sharp cut coat is as being shown in drawing 15 .
[0135] Moreover, the color reproduction nature of an electronic image is further raised to the injection side side of a low pass filter LF by preparing the color filter which low-** transparency of the color of a short wavelength region as shown in drawing 16 , or performing coating.
[0136] The ratio [as opposed to the permeability of wavelength with the highest permeability by this filter or coating] of permeability with a wavelength of 420nm is 15% or more on the wavelength of 400nm - 700nm, and, specifically, it is desirable that the ratio of permeability with a wavelength of 400nm to the permeability of that highest wavelength is 6% or less.
[0137] Thereby, the gap with the recognition over the color of human being's eyes and the color of the image picturized and reproduced can be reduced. In other words, with human being's vision, degradation of the image by the color by the side of the short wavelength which is hard to be recognized being easily recognized by human being's eyes can be prevented.
[0138] If the ratio of permeability with an above-mentioned wavelength of 400nm exceeds 6%, the wavelength which the single wavelength castle which is hard to be recognized by human being's eyes can recognize will be reproduced, conversely, if the ratio of permeability with an above-mentioned wavelength of 420nm is smaller than 15%, playback of the wavelength castle which human being can recognize will become low, and the balance of a color will worsen.
[0139] A means to restrict such wavelength takes effect more in the image pick-up system which used the complementary color mosaic filter.
[0140] In each above-mentioned example, as shown in drawing 16 , permeability [in / for the permeability in the wavelength of 400nm / 420nm] is made into coating which becomes peak 100% of permeability in 440nm 90% 0%.
[0141] By crossing of an operation with the above mentioned near-infrared Sharp cut coat, permeability [in / for permeability / in / for permeability / in / for the permeability in 400nm / 420nm / 600nm / 700nm] is made into 2% 82% 80% 0% with a peak of 99% of permeability with a wavelength of 450nm. Thereby more faithful color reproduction is performed.
[0142] Moreover, whenever [azimuth / at the time of projection on the image surface] is using in piles three kinds of filters which have a crystallographic axis in a horizontal (= 0 degree) and the direction of **45 degree, respectively in the direction of an optical axis, and about each, a low pass filter LF is shifting only SQRT (1/2) x a in amum and the direction of **45 degree horizontally, respectively, and is performing moire control. Here, SQRT is the square root as mentioned above, and means a square root.
[0143] Moreover, on the image pick-up side I of CCD, cyanogen, MAZENDA, yellow, and the complementary color mosaic filter that prepared the color filter of four colors of Green (green) in the shape of a mosaic corresponding to the image pick-up pixel are prepared as shown in drawing 17 . these four kinds of color filters -- each -- abbreviation -- it is arranged in the shape of a mosaic so that it may become the same number, and so that it may not correspond to the color filter of the class with the same adjacent pixel. Thereby more faithful color reproduction becomes possible.
[0144] A complementary color mosaic filter consists of at least four kinds of color filters, as shown in drawing 17 , and specifically, it is [the property of four kinds of the color filter] desirable that it is as follows.
[0145] color filter G of Green -- wavelength GP a spectrum -- a strong peak -- having -- color filter Ye of yellow Wavelength YP a spectrum -- a strong peak -- having -- color filter C of cyanogen -- wavelength CP a spectrum -- having a strong peak, color filter M of MAZENDA has a peak on wavelength MP1 and MP2, and is satisfied with it of the following conditions.
[0146] 2< 640nm of 1< 480nm 580 nm<MP of 510 nm<GP <540nm5 nm<YP-GP <35nm-100 nm<CP-GP <-5nm430 nm<MP further On the wavelength of 530nm, it has 80% or more of reinforcement to a strong peak. the color filter of Green, yellow, and cyanogen -- each spectrum -- As for the color filter of MAZENDA, it is more desirable to have 10 to 50% of reinforcement on the wavelength of 530nm to the peak of optical reinforcement that much, when raising color reproduction nature.
[0147] An example of each wavelength property in each above-mentioned example is shown in drawing 18 . color filter G of Green -- 525nm -- a spectrum -- it has the strong beak. color filter Ye of yellow 555nm -- a spectrum -- it has the strong

peak. color filter C of cyanogen -- 510nm -- a spectrum -- it has the strong peak. Color filter M of MAZENDA has the peak in 445nm and 620nm. moreover, each color filter in 530nm -- each spectrum -- a strong peak -- receiving -- G -- 99% and Ye C is and M may be 38% 97% 95%.

[0148] In the case of such a complementary filter, the controller (or controller used for a digital camera) which is not illustrated performs the following signal processing electrically, and it is a luminance signal.

Y=|G+M+Ye+C|x1/4 chrominance signal

It is changed into the signal of R (red), G (green), and B (blue) through signal processing of R-Y=|(M+Ye)-(G+C)|B-Y=|(M+C)-(G+Ye) |.

[0149] By the way, the arrangement location of the above-mentioned near-infrared Sharp cut coat may be any location on an optical path. Moreover, two sheets or at least one sheet does not matter as the number of sheets of a low pass filter LF was also described above.

[0150] Now, the above electronic image pick-up equipments of this invention can especially be used for the photography equipment which takes a photograph by forming a body image with a zoom lens and making electronic image sensors, such as CCD, receive the image, a digital camera, a video camera and the personal computer that is the example of an information processor, a telephone, especially a cellular phone convenient to carry, etc. Below, the operation gestalt is illustrated.

[0151] Drawing 19 - drawing 21 show the conceptual diagram of a configuration of having built the zoom lens by this invention into the photography optical system 41 of a digital camera. It is the sectional view in which the front perspective view in which drawing 19 shows the appearance of a digital camera 40, and drawing 20 show this back perspective view, and drawing 21 shows the configuration of a digital camera 40. If a digital camera 40 presses the shutter 45 arranged in the upper part of a camera 40 including the photography optical system 41 which has the optical path 42 for photography, the finder optical system 43 which has the optical path 44 for finders, a shutter 45, a flash plate 46, and liquid crystal display monitor 47 grade in the case of this example, it will be interlocked with and photography will be performed through the zoom lens of the photography optical system 41 1, for example, an example. The body image formed of the photography optical system 41 is formed on the image pick-up side of CCD49 through infrared cut absorption filter IF which comes to give a near-infrared cut coat on dummy transparence monotonous, and the optical low pass filter LF. The body image received by this CCD49 is displayed on the liquid crystal display monitor 47 formed in the camera tooth back as an electronic image through the processing means 51. Moreover, it connects with this processing means 51, and the record means 52 can also record the photoed electronic image on it. In addition, this record means 52 may be formed in the processing means 51 and another object, and it may be constituted so that a floppy (trademark) disk, memory card, MO, etc. may perform a record store electronically. Moreover, you may constitute as a film-based camera which has arranged the silver halide film instead of CCD49.

[0152] Furthermore, on the optical path 44 for finders, the object optical system 53 for finders is arranged. The body image formed of this object optical system 53 for finders is formed on the visual field frame 57 of the Porro prism 55 which is an image erection member. Behind this polyp rhythm 55, the eyepiece optical system 59 which leads the image made into the erect normal image to the observer eyeball E is arranged. In addition, the covering member 50 is arranged at the injection side of the eyepiece optical system 59, respectively the incidence side of the photography optical system 41 and the object optical system 53 for finders.

[0153] Thus, the photography optical system 41 is a high variable power ratio in an extensive field angle, aberration is good and the constituted digital camera 40 has it, and since it is the big zoom lens of the back focus which can arrange a filter etc., it can realize high performance and low cost-ization. [bright]

[0154] In addition, in the example of drawing 21 , although the plane-parallel plate is arranged as a covering member 50, a lens with power may be used.

[0155] The electronic image pick-up equipment which has the zoom lens of the above this invention and it can be constituted as follows, for example.

[0156] [1] The 1st lens group which has negative refractive power in order [side / body], and the 2nd lens group which has forward refractive power, Consist of the 3rd lens group which has forward refractive power, and the variable power from the wide angle edge at the time of an infinite distance object point focus to a tele edge is faced. Said 2nd lens group moves only to a body side, and it moves, said 3rd lens group changing spacing with the 2nd lens group. Said 2nd lens group Sequentially from a body side, it consists of a positive lens L21, a negative lens L22, a positive lens L23, and a negative lens L24. It is the zoom lens characterized by for which lens having the aspheric surface and satisfying the following conditions (1) of the positive lens L23 in said 2nd lens group, or a negative lens L24 at least.

[0157]

(1) 0.6<R22R/R21F <2.2 however R21F, and R22R It is the radius of curvature on the optical axis of the field by the side of the body of the positive lens L21 of the 2nd lens group, and the field by the side of the image of the negative lens L22 of the 2nd lens group, respectively.

[0158] [2] The above-mentioned 1 written zoom lens characterized by uniting with the electronic image sensor arranged on an image side.

[0159] In the zoom lens arranged on the image pick-up side side of an electronic image sensor [3] Said zoom lens The 1st lens group which has negative refractive power in order [side / body], and the 2nd lens group which has forward refractive power, Consist of the 3rd lens group which has forward refractive power, and the variable power from the wide angle edge at the time of an infinite distance object point focus to a tele edge is faced. Said 2nd lens group moves only to a body side, and it moves, said 3rd lens group changing spacing with the 2nd lens group. Said 2nd lens group Sequentially from a body side, it consists of a positive lens L21, a negative lens L22, a positive lens L23, and a negative lens L24. It is the zoom lens characterized by for which lens having the aspheric surface and satisfying the following conditions (2) of the positive lens L23 in said 2nd lens group, or a negative lens L24, (3), and (4) at least.

[0160]

(2) 0< (C24F-C23R) and L<1.6 (3) 0.01<d23 / L< 0.2 (4) It corrects -0.4<L/f2R<0.8. C23R =1/R23R, and C24F =1/R24F it is -- here R23R and R24F, respectively The field by the side of the image of the positive lens L23 of the 2nd lens group, The radius of curvature on the optical axis of the field by the side of the body of the negative lens L24 of the 2nd lens group and L The diagonal length of the effective image pick-up field (abbreviation rectangle) of an image sensor (mm), Optical-axis absentminded mind spacing of the positive lens L23 of the 2nd lens group and a negative lens L24 and f2R of d23 are the synthetic focal distances of the positive lens L23 of the 2nd lens group, and a negative lens L24.

[0161] [4] The zoom lens of one above-mentioned publication characterized by uniting with the electronic image sensor arranged on an image side, and satisfying the following conditions (2), (3), and (4).

[0162]

(2) 0< (C24F-C23R) and L<1.6 (3) 0.01<d23 / L< 0.2 (4) It corrects -0.4<L/f2R<0.8. C23R =1/R23R, and C24F =1/R24F it is

-- here R23R and R24F, respectively The field by the side of the image of the positive lens L23 of the 2nd lens group, The radius of curvature on the optical axis of the field by the side of the body of the negative lens L24 of the 2nd lens group and L The diagonal length of the effective image pick-up field (abbreviation rectangle) of an image sensor (mm), Optical-axis absentminded mind spacing of the positive lens L23 of the 2nd lens group and a negative lens L24 and f2R of d23 are the synthetic focal distances of the positive lens L23 of the 2nd lens group, and a negative lens L24.
[0163] [5] The zoom lens of four given in any 1 term from the above 2 characterized by joining the positive lens L21 and negative lens L22 of said 2nd lens group.
[0164] [6] The zoom lens of the above 2-5 characterized by said 2nd lens group satisfying the following conditions (5) given in any 1 term.
[0165]
(5) 25<nu21-nu22+nu23-nu24<55, however nu21, nu22, nu23 and nu24 are the Abbe numbers (d line standard) of the medium of the positive lens L21 of the 2nd lens group, a negative lens L22, a positive lens L23, and a negative lens L24, respectively.
[0166] [7] The zoom lens of the above 2-6 characterized by any satisfying at least the following conditions (6) of said aspheric surface of the positive lens L23 in said 2nd lens group, or a negative lens L24 allotted for any being at least given in any 1 term.
[0167]
(6) 7.5x10-3 and L>|Asp2R |>|Asp21F| It corrects. Asp21F and Asp2R, respectively The field by the side of the body of a positive lens L21, As opposed to the spherical surface which has the radius of curvature on the optical axis of the field of a positive lens L23 or a negative lens L24 The height from an optical axis is the diagonal length (mm) of the effective image pick-up field (abbreviation rectangle) of an image sensor, and the amount of aspheric surface deflections in 0.3L and L set amount Aspof aspheric surface deflections21F to 0, when the body side face of a positive lens L21 is the spherical surface.
[0168] [8] The zoom lens of the above 2-7 characterized by satisfying the following conditions (7) given in any 1 term.
[0169]
(7) -0.5<(R21F-R22R)/(R21F+R22R) <0.3 however R21F, and R22R It is the radius of curvature on the optical axis of the field by the side of the body of the positive lens L21 of the 2nd lens group, and the field by the side of the image of a negative lens L22, respectively.
[0170] [9] The zoom lens of the above 2-8 characterized by satisfying the following conditions (8) and (9) given in any 1 term.
[0171] (8) -1<f3/f2R<1.6 (9) It corrects 0.02<d22/L<0.5. f2R and f3, respectively The synthetic focal distance of the positive lens L23 of the 2nd lens group, and a negative lens L24, and the focal distance of the 3rd lens group, d22 is spacing of the image side face of the negative lens L22 of the 2nd lens group, and the body side face of a positive lens L23, and L is the diagonal length (mm) of the effective image pick-up field (abbreviation rectangle) of an image sensor.
[0172] [10] A zoom lens the above 1 which satisfies the following conditions (10) thru/or given in any 1 term of 9.
[0173] (10) -1<f2 F/R21R <2.5, however R21R The radius of curvature of the field by the side of the image of the positive lens L21 of the 2nd lens group and f2F are the synthetic focal distances of the positive lens L21 of the 2nd lens group, and a negative lens L22.
[0174] [11] It is the zoom lens of ten given in any 1 term from the above 1 characterized by said 3rd lens group moving to an image side by the locus of a convex in case variable power is carried out to a tele edge from a wide angle edge.
[0175] [12] The zoom lens of 11 given in any 1 term from the above 1 characterized by focusing by moving said 3rd lens group in accordance with an optical axis.
[0176] [13] Wide angle edge half field angle omega W Zoom lens of 12 given in any 1 term from the above 1 characterized by being in the range of 27 to 42 degrees.
[0177] [14] Electronic image pick-up equipment characterized by having the zoom lens of 13 given in any 1 term from the above 1.
[0178]
[Effect of the Invention] The zoom lens which excelled [thickness / collapsing] in storability thinly, and excelled [scale factor / high] in the image formation engine performance also in the rear focus by this invention can be obtained, and it becomes possible to attain thorough thin shape-ization of a video camera or a digital camera.

[Translation done.]

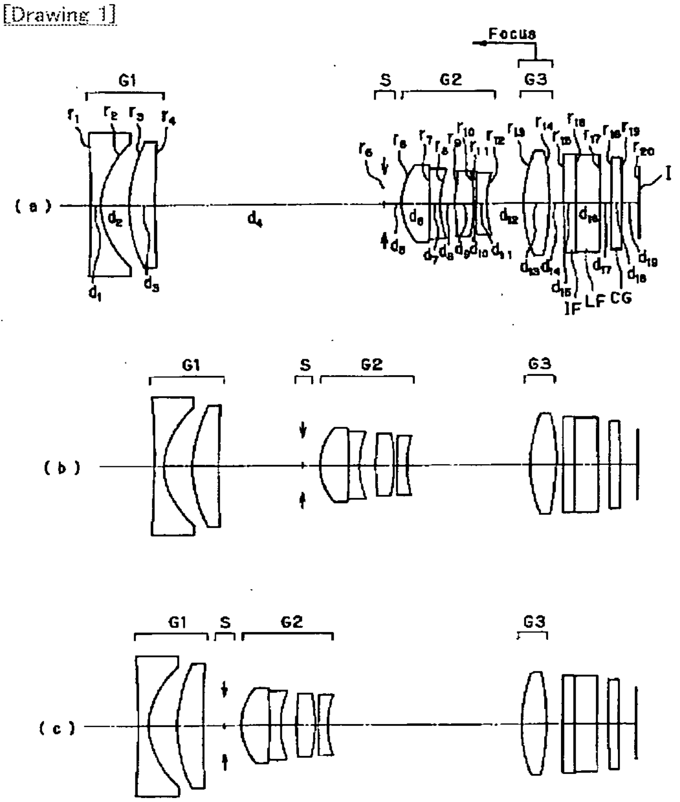
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] They are the wide angle edge at the time of the infinite distance object point focus of the example 1 of the zoom lens used for the electronic image pick-up equipment of this invention (a), an intermediate state (b), and a lens sectional view in a tele edge (c).
[Drawing 2] It is the same lens sectional view as drawing 1 of the zoom lens of an example 2.
[Drawing 3] It is the same lens sectional view as drawing 1 of the zoom lens of an example 3.
[Drawing 4] It is the same lens sectional view as drawing 1 of the zoom lens of an example 4.
[Drawing 5] It is the same lens sectional view as drawing 1 of the zoom lens of an example 5.
[Drawing 6] It is the same lens sectional view as drawing 1 of the zoom lens of an example 6.
[Drawing 7] It is the same lens sectional view as drawing 1 of the zoom lens of an example 7.
[Drawing 8] It is the same lens sectional view as drawing 1 of the zoom lens of an example 8.
[Drawing 9] It is the same lens sectional view as drawing 1 of the zoom lens of an example 9.
[Drawing 10] It is the same lens sectional view as drawing 1 of the zoom lens of an example 10.
[Drawing 11] It is an aberration Fig. at the time of the infinite distance object point focus of an example 1.
[Drawing 12] It is an aberration Fig. at the time of photographic subject distance the focus of 10cm of an example 1.
[Drawing 13] It is drawing for explaining the definition of the amount of aspheric surface deflections which can set this invention.
[Drawing 14] It is drawing for explaining the diagonal length of the effective image pick-up side in the case of taking a photograph with an electronic image sensor.
[Drawing 15] It is drawing showing the permeability property of an example of a near-infrared Sharp cut coat.
[Drawing 16] It is drawing showing the permeability property of an example of a color filter prepared in the injection side side of a low pass filter.
[Drawing 17] It is drawing showing color filter arrangement of a complementary color mosaic filter.
[Drawing 18] It is drawing showing an example of the wavelength property of a complementary color mosaic filter.
[Drawing 19] It is the front perspective view showing the appearance of the digital camera incorporating the zoom lens by this invention.
[Drawing 20] It is the back perspective view of the digital camera of drawing 19 .
[Drawing 21] It is the sectional view of the digital camera of drawing 19 .
[Description of Notations]
G1 -- The 1st lens group
G2 -- The 2nd lens group
G3 -- The 3rd lens group
S -- Aperture diaphragm
IF -- Infrared cut absorption filter
LF -- Low pass filter
CG -- Cover glass
I -- Image surface
E -- Observer eyeball
40 -- Digital camera
41 -- Photography optical system
42 -- Optical path for photography
43 -- Finder optical system
44 -- Optical path for finders
45 -- Shutter
46 -- Flash plate
47 -- Liquid crystal display monitor
49 -- CCD
50 -- Covering member
51 -- Processing means
52 -- Record means
53 -- Object optical system for finders
55 -- Porro prism
57 -- Visual field frame
59 -- Eyepiece optical system

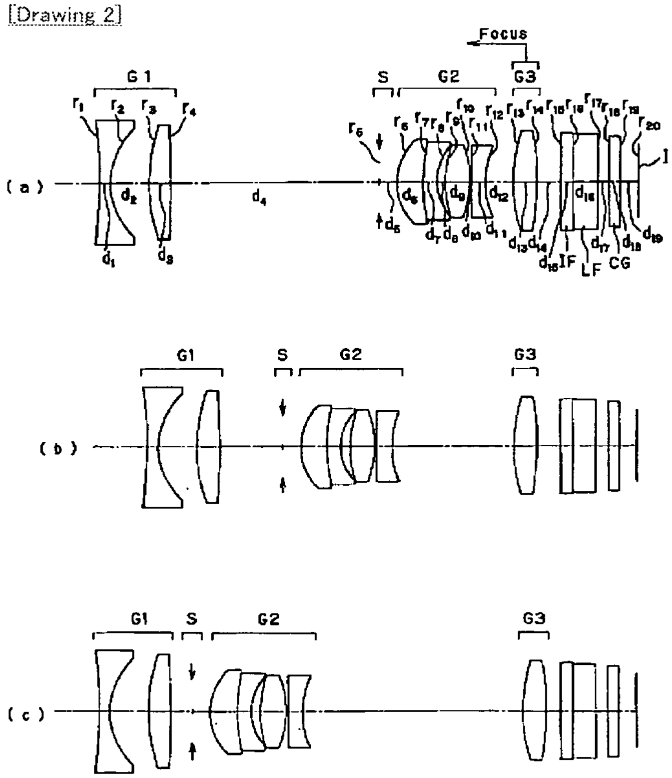
[Translation done.]

DRAWINGS

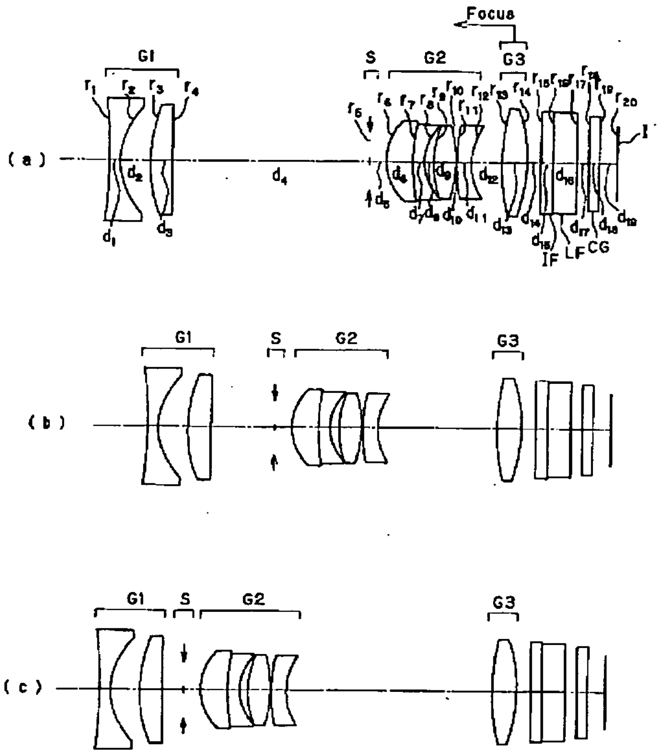
[Drawing 1]



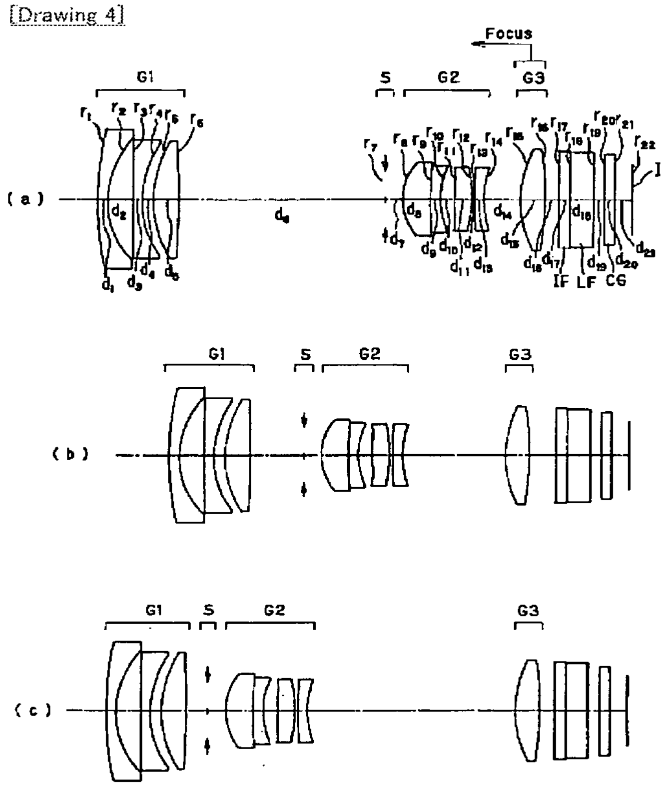
[Drawing 2]



[Drawing 3]



[Drawing 4]



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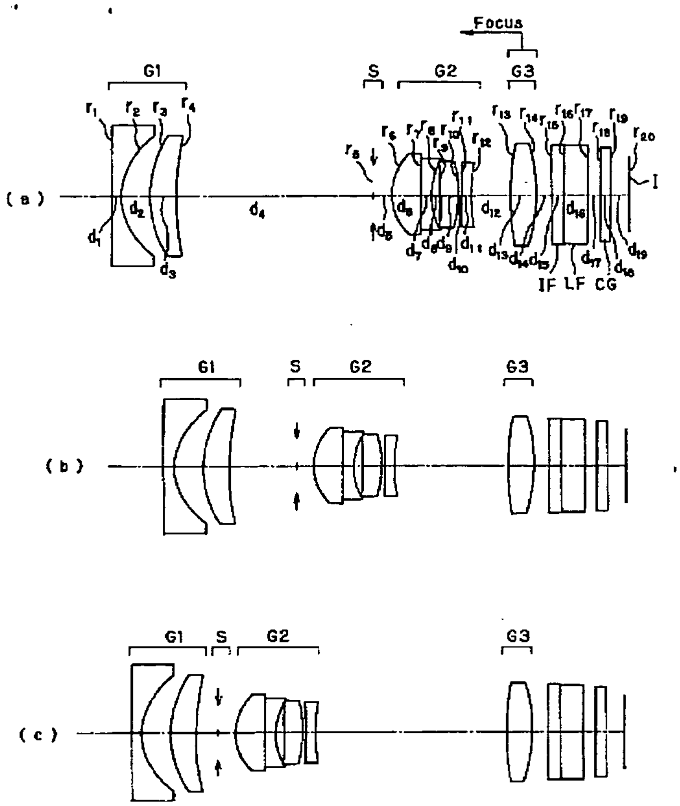

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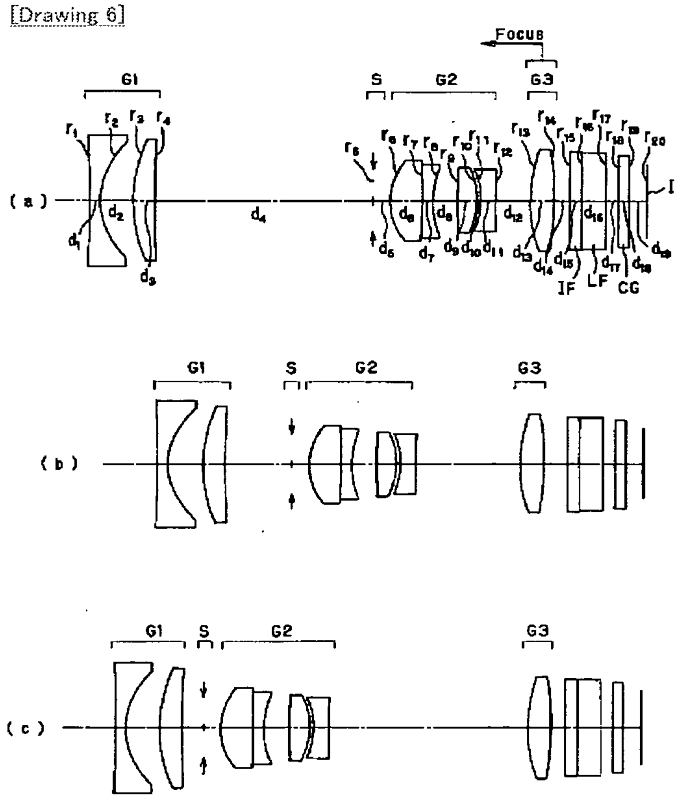

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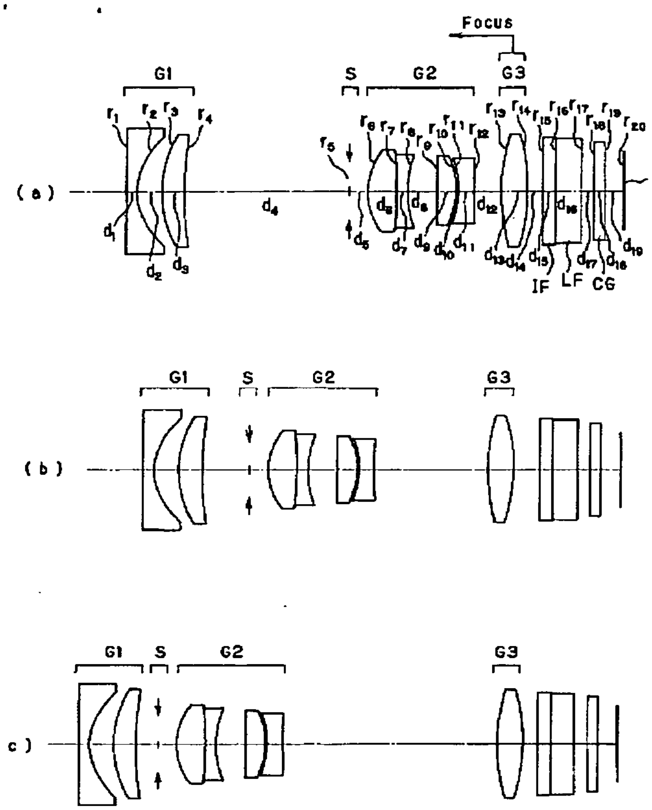

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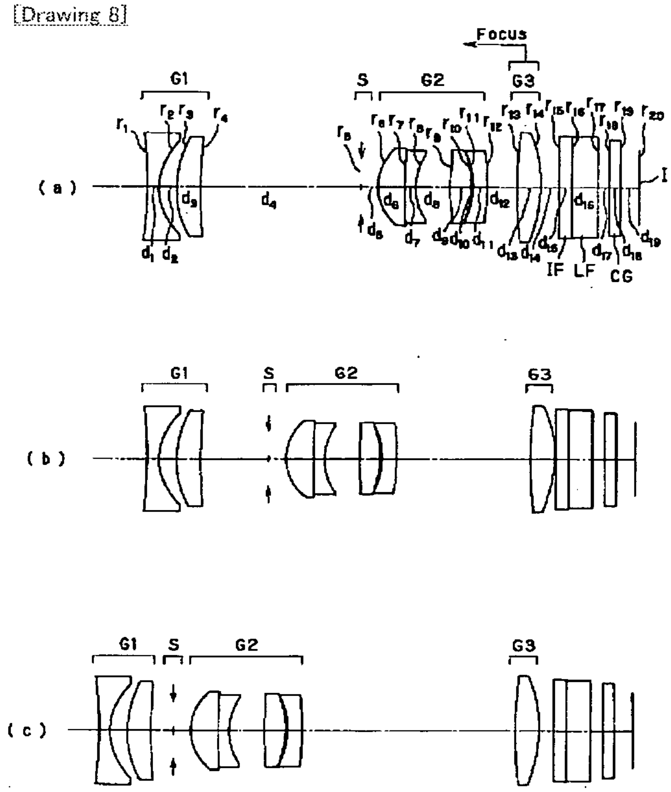
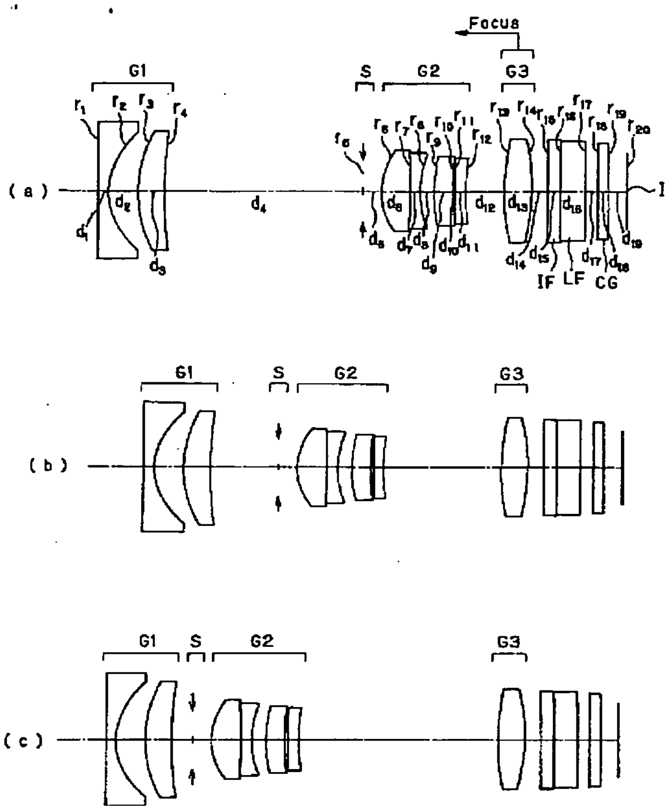


[Drawing 9]



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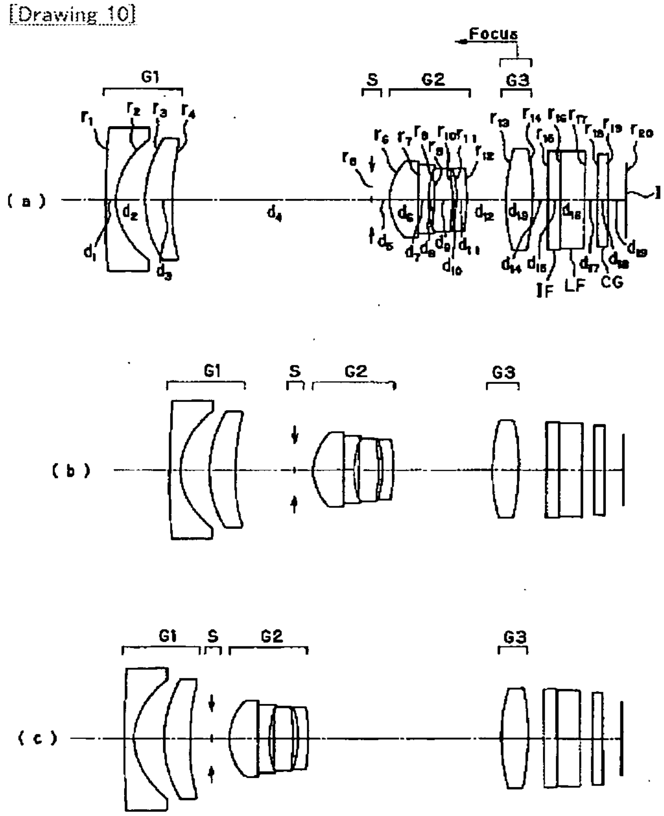
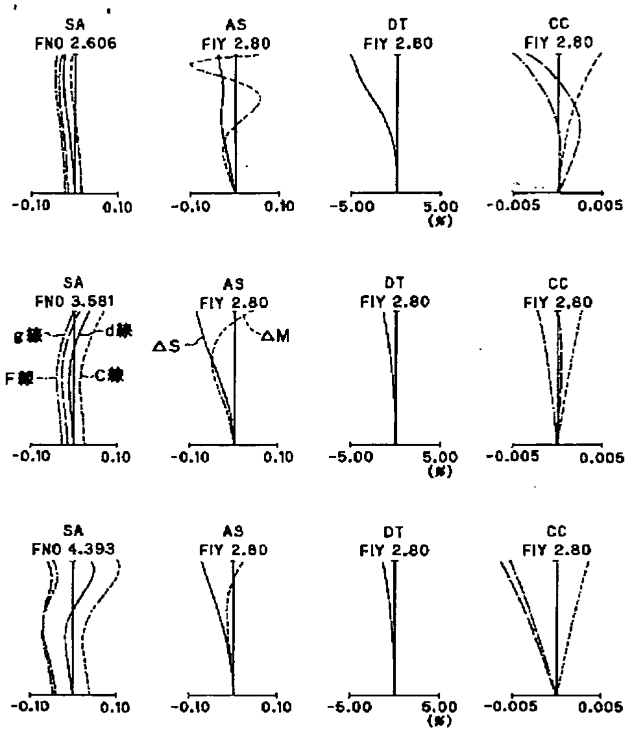
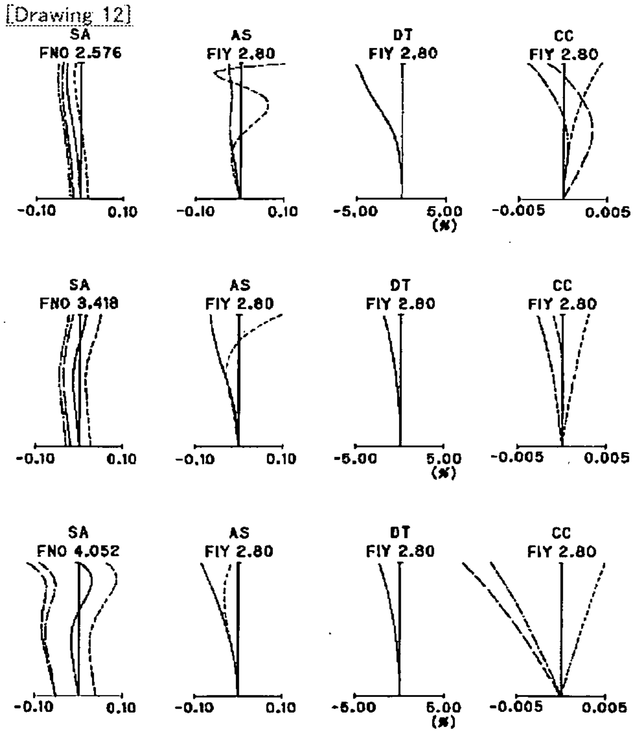


[Drawing 11]



[Drawing 12]



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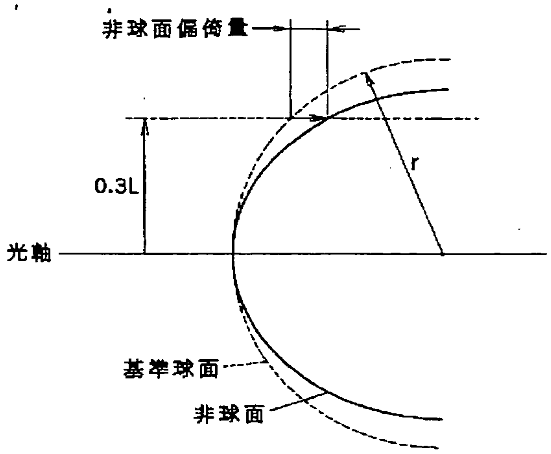

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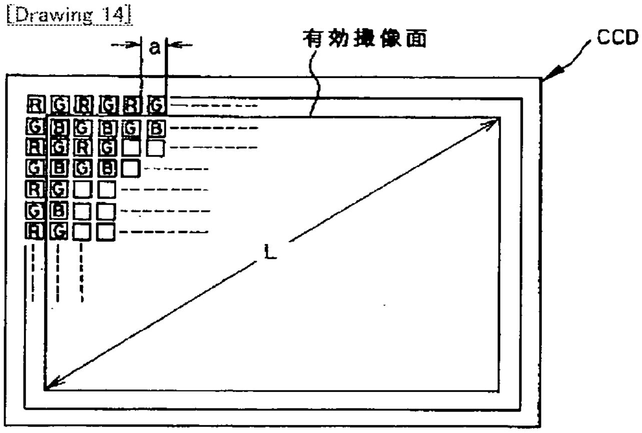

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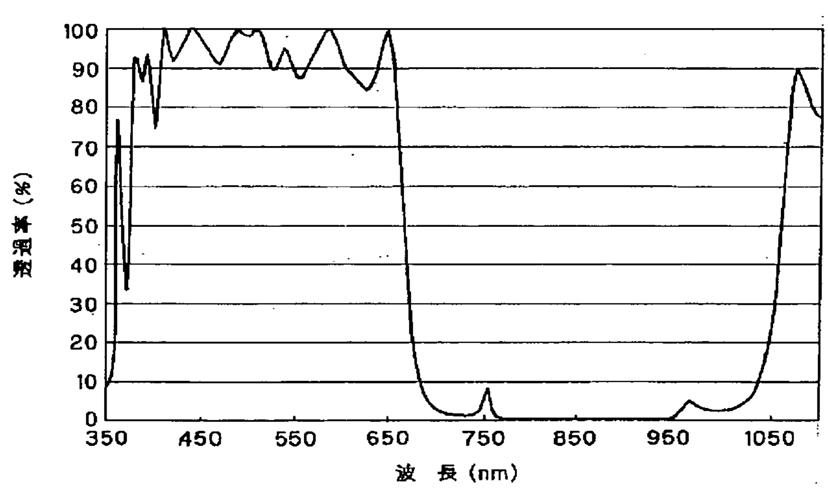
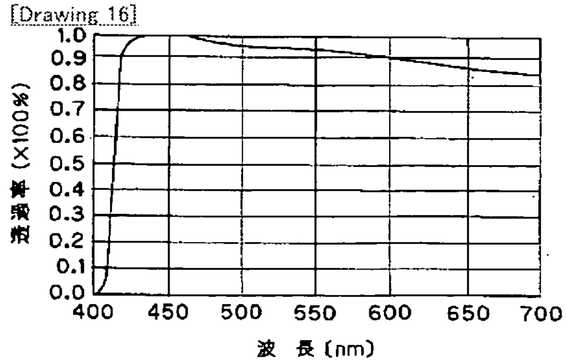
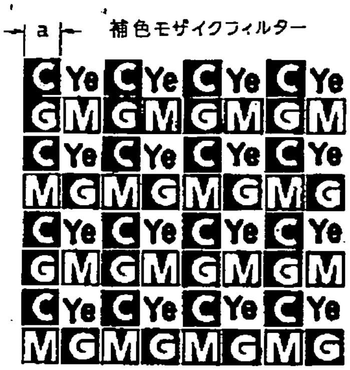


[Drawing 16]

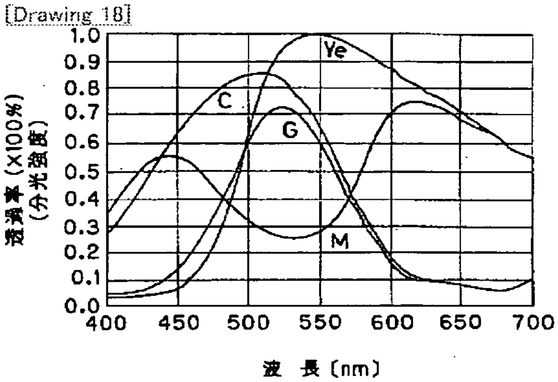


[Drawing 17]

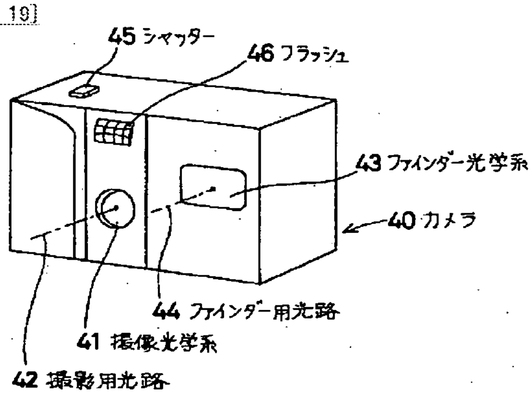


C:シアン M:マゼンタ
Ye:イエロー G:緑

[Drawing 18]



[Drawing 19]



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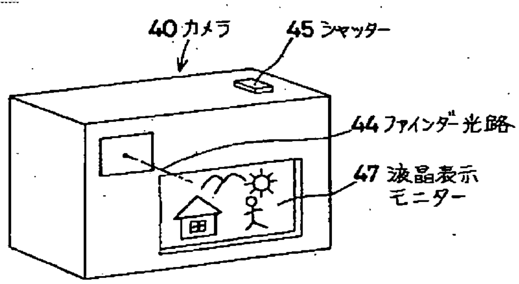
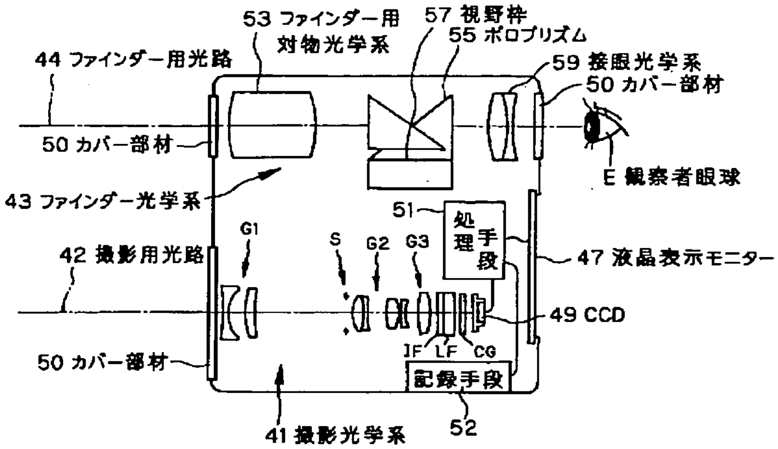


[Drawing 21]



[Translation done.]

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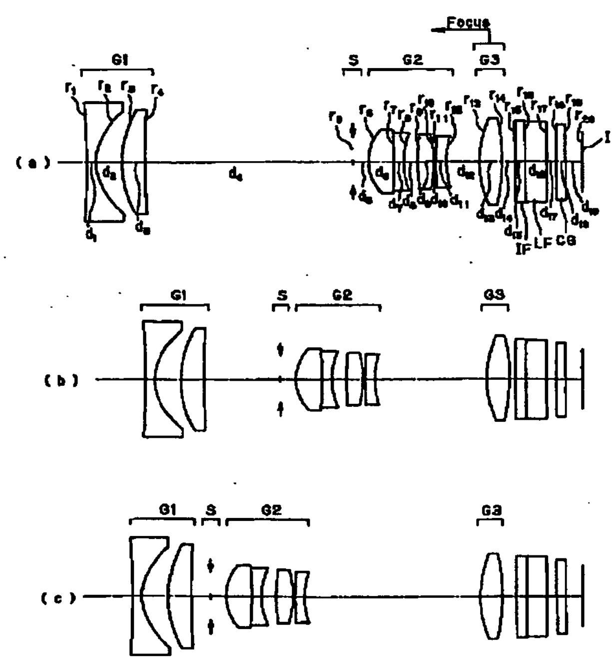
最終頁に続く

(54)【発明の名称】 ズームレンズ及びそれを有する電子撮像装置

(57)【要約】

【課題】 構成枚数が少なく、小型で簡素にしやすく、高い結像性能を有するズーム方式を用いてビデオカメラやデジタルカメラの徹底的薄型化を図ること。

【解決手段】 負の第1群G1と、開口絞りSと、正の第2群G2と、正の第3群G3とからなり、広角端から望遠端への変倍に際して、第2群G2が物体側へのみ移動し、第3群G3が第2群G2との間隔を変化させつつ移動し、第2群G2は正レンズ、負レンズ、正レンズ、負レンズにて構成され、第2群G2中の像側の正レンズ又は負レンズの少なくとも何れかのレンズは非球面を有し、かつ、第2群G2の物体側の正レンズの物体側の面と、物体側の負レンズの像側の面の光軸上の曲率半径の比に関する条件（1）を満足する。



【特許請求の範囲】

【請求項１】　物体側より順に、負の屈折力を有する第１レンズ群と、正の屈折力を有する第２レンズ群と、正の屈折力を有する第３レンズ群よりなり、無限遠物点合焦時における広角端から望遠端への変倍に際して、前記第２レンズ群が物体側へのみ移動し、前記第３レンズ群が第２レンズ群との間隔を変化させつつ移動し、前記第２レンズ群は、物体側から順に、正レンズＬ２１、負レンズＬ２２、正レンズＬ２３、負レンズＬ２４にて構成され、前記第２レンズ群中の正レンズＬ２３又は負レンズＬ２４の少なくとも何れかのレンズは非球面を有し、かつ、以下の条件（1）を満足することを特徴とするズームレンズ。

（1）　$0.6 < R_{22R} / R_{21F} < 2.2$

ただし、R_{21F}、R_{22R} はそれぞれ第２レンズ群の正レンズＬ２１の物体側の面、第２レンズ群の負レンズＬ２２の像側の面の光軸上の曲率半径である。

【請求項２】　像側に配される電子撮像素子と一体化されたことを特徴とする請求項１記載ズームレンズ。

【請求項３】　電子撮像素子の撮像面側に配されるズームレンズにおいて、

前記ズームレンズは、物体側より順に、負の屈折力を有する第１レンズ群と、正の屈折力を有する第２レンズ群と、正の屈折力を有する第３レンズ群よりなり、無限遠物点合焦時における広角端から望遠端への変倍に際して、前記第２レンズ群が物体側へのみ移動し、前記第３レンズ群が第２レンズ群との間隔を変化させつつ移動し、前記第２レンズ群は、物体側から順に、正レンズＬ２１、負レンズＬ２２、正レンズＬ２３、負レンズＬ２４にて構成され、前記第２レンズ群中の正レンズＬ２３又は負レンズＬ２４の少なくとも何れかのレンズは非球面を有し、かつ、以下の条件（2）、（3）、（4）を満足することを特徴とするズームレンズ。

（2）　$0 < (C_{24F} - C_{23R}) \cdot L < 1.6$

（3）　$0.01 < d_{23} / L < 0.2$

（4）　$-0.4 < L / f_{2R} < 0.8$

ただし、$C_{23R} = 1 / R_{23R}$、$C_{24F} = 1 / R_{24F}$ であり、ここで、R_{23R}、R_{24F} はそれぞれ第２レンズ群の正レンズＬ２３の像側の面、第２レンズ群の負レンズＬ２４の物体側の面の光軸上の曲率半径、Ｌは撮像素子の有効撮像領域（略矩形）の対角長（mm）、d_{23}は第２レンズ群の正レンズＬ２３と負レンズＬ２４との光軸上の空気間隔、f_{2R}は第２レンズ群の正レンズＬ２３と負レンズＬ２４との合成焦点距離である。

【請求項４】　請求項１から３の何れか１項記載のズームレンズを備えたことを特徴とする電子撮像装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、ズームレンズ及びそれを有する電子撮像装置に関し、特に、ズームレンズ等の光学系部分の工夫により奥行き方向の薄型化を実現した、ビデオカメラやデジタルカメラ等の電子撮像装置あるいはズームレンズに関するものである。また、そのズームレンズはリアフォーカスを可能にならしめたものに関するものである。

【０００２】

【従来の技術】近年、銀塩３５mmフィルム（通称ライカ版）カメラに代わる次世代カメラとしてデジタルカメラ（電子カメラ）が注目されてきている。さらに、それは業務用高機能タイプからポータブルな普及タイプまで幅広い範囲でいくつものカテゴリーを有するようになってきている。

【０００３】本発明においては、特にポータブルな普及タイプのカテゴリーに注目し、高画質を確保しながら奥行きの薄いビデオカメラ、デジタルカメラを実現する技術を提供することをねらっている。カメラの奥行き方向を薄くするのに最大のネックとなっているのは、光学系、特にズームレンズ系の最も物体側の面から撮像面までの厚みである。最近では、撮影時に光学系をカメラボディ内からせり出し携帯時に光学系をカメラボディ内に収納するいわゆる沈胴式鏡筒を採用することが主流になっている。

【０００４】しかしながら、使用するレンズタイプやフィルターによって光学系沈胴時の厚みが大きく異なる。特にズーム比やＦ値等、仕様を高く設定するには、最も物体側のレンズ群が正の屈折力を有するいわゆる正先行型ズームレンズは、各々のレンズエレメントの厚みやデッドースペースが大きく、沈胴してもたいして厚みが薄くならない（特開平１１－２５８５０７号）。負先行型で特に２乃至３群構成のズームレンズはその点有利であるが、群内構成枚数が多かったり、エレメントの厚みが大きかったり、最も物体側のレンズが正レンズの場合も沈胴しても薄くならない（特開平１１－５２２４６号）。現在知られている中で電子撮像素子用に適しかつズーム比、画角、Ｆ値等を含めた結像性能が良好で沈胴厚を最も薄くできる可能性を有するものの例として、特開平１１－２８７９５３号、特開２０００－２６７００９、特開２０００－２７５５２０等のものがある。

【０００５】第１群を薄くするには入射瞳位置を浅くするのがよいが、そのためには第２群の倍率を高くすることになる。一方、そのために第２群の負担が大きくなりそれ自身を薄くすることが困難になるばかりでなく、収差補正の困難さや製造誤差の効きが増大し好ましくない。薄型化、小型化を実施するには、撮像素子を小さくすればよいが、同じ画素数とするためには画素ピッチを小さくする必要があり、感度不足を光学系でカバーしなければならない。回折の影響も然りである。

【０００６】また、奥行きの薄いカメラボディにするために、合焦時のレンズ移動を前群ではなくいわゆるリアフォーカスで行うのが駆動系のレイアウト上有効であ

る。すると、リアフォーカスを実施したときの収差変動が少ない光学系を選択する必要が出てくる。

【０００７】

【発明が解決しようとする課題】本発明は従来技術のこのような状況に鑑みてなされたものであり、その目的は、構成枚数が少なく、リアフォーカス方式等機構レイアウト上小型で簡素にしやすく、無限遠から近距離まで安定した高い結像性能を有するズーム方式あるいはズーム構成を選択し、さらには、ズームレンズの各レンズエレメントを薄くして各群の総厚を薄くしたり、フィルター類の選択をも考慮して、ビデオカメラやデジタルカメラの徹底的薄型化を図ることである。

【０００８】

【課題を解決するための手段】上記目的を達成するために、本発明のズームレンズは、物体側より順に、負の屈折力を有する第１レンズ群と、正の屈折力を有する第２レンズ群と、正の屈折力を有する第３レンズ群よりなり、無限遠物点合焦時における広角端から望遠端への変倍に際して、前記第２レンズ群が物体側へのみ移動し、前記第３レンズ群が第２レンズ群との間隔を変化させつつ移動し、前記第２レンズ群は、物体側から順に、正レンズＬ２１、負レンズＬ２２、正レンズＬ２３、負レンズＬ２４にて構成され、前記第２レンズ群中の正レンズＬ２３又は負レンズＬ２４の少なくとも何れかのレンズは非球面を有し、かつ、以下の条件（１）を満足することを特徴とするものである。

【０００９】

（１）　$0.6 < R_{22R} / R_{21F} < 2.2$

ただし、R_{21F}、R_{22R} はそれぞれ第２レンズ群の正レンズＬ２１の物体側の面、第２レンズ群の負レンズＬ２２の像側の面の光軸上の曲率半径である。

【００１０】この場合、像側に配される電子撮像素子と一体化されていることが望ましい。

【００１１】また、本発明のズームレンズは、電子撮像素子の撮像面側に配されるズームレンズにおいて、前記ズームレンズは、物体側より順に、負の屈折力を有する第１レンズ群と、正の屈折力を有する第２レンズ群と、正の屈折力を有する第３レンズ群よりなり、無限遠物点合焦時における広角端から望遠端への変倍に際して、前記第２レンズ群が物体側へのみ移動し、前記第３レンズ群が第２レンズ群との間隔を変化させつつ移動し、前記第２レンズ群は、物体側から順に、正レンズＬ２１、負レンズＬ２２、正レンズＬ２３、負レンズＬ２４にて構成され、前記第２レンズ群中の正レンズＬ２３又は負レンズＬ２４の少なくとも何れかのレンズは非球面を有し、かつ、以下の条件（２）、（３）、（４）を満足することを特徴とするものである。

【００１２】

（２）　$0 < (C_{24F} - C_{23R}) \cdot L < 1.6$

（３）　$0.01 < d_{23} / L < 0.2$

（４）　$-0.4 < L / f_{2R} < 0.8$

ただし、$C_{23R} = 1 / R_{23R}$、$C_{24F} = 1 / R_{24F}$ であり、ここで、R_{23R}、R_{24F} はそれぞれ第２レンズ群の正レンズＬ２３の像側の面、第２レンズ群の負レンズＬ２４の物体側の面の光軸上の曲率半径、Ｌは撮像素子の有効撮像領域（略矩形）の対角長（ｍｍ）、d_{23}は第２レンズ群の正レンズＬ２３と負レンズＬ２４との光軸上の空気間隔、f_{2R}は第２レンズ群の正レンズＬ２３と負レンズＬ２４との合成焦点距離である。

【００１３】本発明は、これらのズームレンズを備えた電子撮像装置を含むものである。

【００１４】以下、本発明において上記構成をとる理由と作用を説明する。

【００１５】本発明において、物体側より順に、負の屈折力を有する第１レンズ群と、正の屈折力を有する第２レンズ群と、正の屈折力を有する第３レンズ群よりなり、無限遠物点合焦時に広角端から望遠端への変倍を、第２レンズ群の物体側への単調な移動と、第３レンズ群の第２レンズ群とは異なる量の移動により行なうズームレンズにおいて、第２レンズ群が、物体側から順に、正レンズＬ２１、負レンズＬ２２、正レンズＬ２３、負レンズＬ２４にて構成したズームレンズを採用している。

【００１６】なお、本発明において、レンズとは、単一の媒体からなるレンズを１単位とし、接合レンズは複数のレンズからなるものを意味する。

【００１７】古くから銀塩フィルムカメラ用ズームレンズとしてよく使用される負正の２群ズームにおいて、それを小型化するために各焦点距離における正の後群（第２レンズ群）の倍率を高くするのがよいが、そのために、第２レンズ群のさらに像側に１枚の正レンズを第３レンズ群として加え、広角端から望遠端に変倍する際に第２レンズ群との間隔を変化させるという方法がよく知られている。また、この第３レンズ群はフォーカス用としても使用できる可能性を有している。そして、本発明の目的の達成、つまり、沈胴収納時のレンズ部総厚を薄くしてなおかつ第３レンズ群にてフォーカスをする際、非点収差を始めとする軸外収差の変動を抑制するために、第２レンズ群は、物体側から順に、正レンズと負レンズ及びこれに少なくとも正レンズを加えて構成することが必要不可欠要件で、さらに像側に負レンズを加えるとよい。

【００１８】第３レンズ群にてフォーカスをする場合、収差変動が問題になるが、第３レンズ群に必要以上の量の非球面が入ると、その効果を出すために第１レンズ群・第２レンズ群で残存する非点収差を第３レンズ群にて補正することになり、ここで第３レンズ群がフォーカスのために動くと、そのバランスが崩れてしまい好ましくない。したがって、第３レンズ群でフォーカスする場合は、第１レンズ群・第２レンズ群で非点収差をズーム全域に亘り略取り切らねばならない。よって、第３レンズ

群は球面系又は少ない非球面量にて構成し、開口絞りを第２レンズ群の物体側に配し、第２レンズ群は、正レンズ、負レンズ、正レンズ、そして負レンズの順に構成するのがよい。また、このタイプでは前玉径が大きくなり難いので、開口絞りを第２レンズ群と一体（後記の本発明の実施例では、第２レンズ群の直前に配置し第２レンズ群と一体）とした方が、機構上単純であるばかりでなく、沈胴時のデッドスペースが発生し難く、広角端と望遠端のＦ値差が小さい。また、第２レンズ群の物体側の正レンズと負レンズはそれらの相対的偏心による収差の発生が著しいので、これらは接合レンズにした方がよい。接合にする場合は、できるだけ接合レンズ内（正レンズＬ２１、負レンズＬ２２）で収差をキャンセルして偏心敏感度を小さくするのがよい。

【００１９】そこで、第２レンズ群の正レンズ２１、負レンズＬ２２に関して以下の条件式を満足するのがよい。

【００２０】

（１）　$0.6 < R_{22R} / R_{21F} < 2.2$

ただし、R_{21F}、R_{22R} はそれぞれ第２レンズ群の正レンズＬ２１の物体側の面、第２レンズ群の負レンズＬ２２の像側の面の光軸上の曲率半径である。

【００２１】条件（１）の上限の２．２を越えると、全系収差の球面収差・コマ収差・非点収差の補正には有利だが、接合による偏心敏感度の緩和の効果が少ない。下限の０．６を越えると、全系収差の球面収差・コマ収差・非点収差の補正が困難になりやすい。

【００２２】なお、以下のようにするとよりよい。

【００２３】

（１－１）　$1.0 < R_{22R} / R_{21F} < 2.0$

さらに、以下のようにすると最もよい。

【００２４】

（１－２）　$1.4 < R_{22R} / R_{21F} < 1.8$

さらに、第２レンズ群の正レンズＬ２３と負レンズＬ２４に関して、以下の条件式を満足するのがよい。

【００２５】

（２）　$0 < (C_{24F} - C_{23R}) \cdot L < 1.6$

（３）　$0.01 < d_{23} / L < 0.2$

（４）　$-0.4 < L / f_{2R} < 0.8$

ただし、$C_{23R} = 1 / R_{23R}$、$C_{24F} = 1 / R_{24F}$ であり、ここで、R_{23R}、R_{24F} はそれぞれ第２レンズ群の正レンズＬ２３の像側の面、第２レンズ群の負レンズＬ２４の物体側の面の光軸上の曲率半径、Ｌは撮像素子の有効撮像領域（略矩形）の対角長（ｍｍ）、d_{23}は第２レンズ群の正レンズＬ２３と負レンズＬ２４との光軸上の空気間隔、f_{2R}は第２レンズ群の正レンズＬ２３と負レンズＬ２４との合成焦点距離である。

【００２６】条件（２）の下限値の０を越えると、球面収差が発生しやすく、上限値の１．６を越えると、第1レンズ群に非球面を導入しても非点収差を補正しきれない。

【００２７】本発明では、第２レンズ群の正レンズＬ２３と負レンズＬ２４を接合せずに、両者の隣接する面の形状を収差補正のために有効に使うことを目的としている。条件（３）の下限値の０．０１を越えると、正レンズＬ２３と負レンズＬ２４の面干渉が有効径内にまで及びやすい。上限値の０．２を越えると、レンズ径が分厚くなりやすい。

【００２８】条件（４）の下限値の－０．４を越えると、射出瞳位置が像面に接近しシェーディングを引き起こしやすく、また、正レンズＬ２１と負レンズＬ２２を接合とする場合、偏心敏感度は正レンズＬ２１と負レンズＬ２２に集中させる方が都合がよいため、その場合は、できれば正の値になるようにした方がよい。上限値の０．８を越えると、小型で高いズーム比を確保し難い。

【００２９】なお、条件（２）～（４）の何れかあるいは複数を以下のようにするとよりよい。

【００３０】

（２）’　$0.15 < (C_{24F} - C_{23R}) \cdot L < 1.3$

（３）’　$0.01 < d_{23} / L < 0.15$

（４）’　$-0.3 < L / f_{2R} < 0.5$

さらに、条件（２）～（４）の何れかあるいは複数を以下のようにするとさらによい。特に全てを以下のようにすると最もよい。

【００３１】

（２）”　$0.3 < (C_{24F} - C_{23R}) \cdot L < 1$

（３）”　$0.01 < d_{23} / L < 0.1$

（４）”　$-0.2 < L / f_{2R} < 0.2$

また、収差補正のための非球面レンズは、第１レンズ群に歪曲収差・非点収差・コマ収差補正のために１枚と、第２レンズ群に球面収差のために２枚の全系で合計３枚とするのがよい。それ以上入れても効果は少なく、コスト高になるだけである。

【００３２】また、軸上色収差や倍率色収差補正について、以下の条件を満たすとよい。

【００３３】

（５）　$25 < \nu_{21} - \nu_{22} + \nu_{23} - \nu_{24} < 55$

ただし、ν_{21}、ν_{22}、ν_{23}、ν_{24}はそれぞれ第２レンズ群の正レンズＬ２１、負レンズＬ２２、正レンズＬ２３、負レンズＬ２４の媒質のアッベ数（ｄ線基準）である。

【００３４】条件（５）の下限値２５を越えると、軸上色収差・倍率色収差が補正不足になりやすく、上限値の５５を越えると、これらが補正過剰になりやすい。

【００３５】なお、以下のようにするとよりよい。

【００３６】

（５）’　$25<\nu_{21}-\nu_{22}+\nu_{23}-\nu_{24}<50$

さらに、以下のようにすると最もよい。

【００３７】

（５）”　$30<\nu_{21}-\nu_{22}+\nu_{23}-\nu_{24}<50$

次に、第２レンズ群の正レンズＬ２３、負レンズＬ２４の非球面について、以下の条件を満足するとよい。

【００３８】

（６）　$7.5\times10^{-3}\cdot L>|Asp2R|>|Asp21F|$

ただし、Asp21F、Asp2R はそれぞれ正レンズＬ２１の物体側の面、正レンズＬ２３又は負レンズＬ２４の面の光軸上での曲率半径を有する球面に対し、光軸からの高さが０．３Ｌでの非球面偏倚量、Ｌは撮像素子の有効撮像領域（略矩形）の対角長（ｍｍ）であり、正レンズＬ２１の物体側面が球面の場合は非球面偏倚量Asp21Fを０とする。

【００３９】すなわち、本発明でいう非球面偏倚量は、図１３に示すように、対象とする非球面の光軸上での曲率半径ｒを有する球面（基準球面）に対し、電子撮像素子の有効撮像領域の対角長をＬとするとき、光軸からの高さが０．３Ｌの位置でのその非球面の偏倚量を言うものである。

【００４０】条件（６）のように、正レンズＬ２３又は負レンズＬ２４にある程度の非球面を導入しないと、球面収差・コマ収差・非点収差が十分に補正できない。正レンズＬ２１より非球面度が少ないと、コマ収差・非点収差の補正が不十分となりやすい。その上限値の７．５×１０$^{-3}$・Ｌを越えると、正レンズＬ２３又は負レンズＬ２４の偏心敏感度が大きくなりすぎ、部品精度や組み立て精度が厳しくなり好ましくない。なお、正レンズＬ２１の物体側の面は球面でも構わない。

【００４１】なお、以下のようにするとよりよい。

【００４２】

（６）’　$5.0\times10^{-3}\cdot L>|Asp2R|>|Asp21F|$

さらに、以下のようにすると最もよい。

【００４３】

（６）”　$2.5\times10^{-3}\cdot L>|Asp2R|>|Asp21F|$

別の条件として、以下を満たすとよりよい。

【００４４】

（６－２）　$|Asp2R|>3\cdot|Asp21F|$

さらに、以下のようにすると最もよい。

【００４５】

（６－３）　$|Asp2R|>6\cdot|Asp21F|$

また、条件（２）系に対し、さらに以下の条件を満足すると、球面収差の補正上よい。

【００４６】

（７）　$-0.5<(R_{21F}-R_{22R})/(R_{21F}+R_{22R})<0.3$

ただし、R_{21F}、R_{22R} はそれぞれ第２レンズ群の正レンズＬ２１の物体側の面と負レンズＬ２２の像側の面の光軸上の曲率半径である。因みに、この条件式は通常のシェープファクターの逆数になっている。

【００４７】この条件の下限の－０．５を越えると、球面収差補正不足になりやすく、レンズ厚みが厚くなりやすい。また、物体側正レンズＬ２１の加工性も悪化する。上限の０．３を越えると、逆に高次の球面収差が発生したり負レンズ側の深い凹面の加工性が悪化する。

【００４８】なお、以下のようにするとよりよい。

【００４９】

（７）’　$-0.4<(R_{21F}-R_{22R})/(R_{21F}+R_{22R})<0.2$

さらに、以下のようにすると最もよい。

【００５０】

（７）”　$-0.3<(R_{21F}-R_{22R})/(R_{21F}+R_{22R})<0.1$

また、条件（２）系又は（７）系に対し、さらに以下の条件を（８）、（９）の何れかあるいは両方を満足すると、射出瞳位置つまりシェーディングに関して有利である。

【００５１】（８）　$-1<f_3/f_{2R}<1.6$

（９）　$0.02<d_{22}/L<0.5$

ただし、f_{2R}とf_3 はそれぞれ第２レンズ群の正レンズＬ２３と負レンズＬ２４との合成焦点距離と第３レンズ群の焦点距離、d_{22}は第２レンズ群の負レンズＬ２２の像側面と正レンズＬ２３の物体側面との間隔、Ｌは撮像素子の有効撮像領域（略矩形）の対角長（ｍｍ）である。

【００５２】条件（８）の上限値の１．６を越えると、広角端における射出瞳位置つまりシェーディングには有利であるが、望遠端に変倍する際の射出瞳位置の変動量が大きく、望遠端でのシェーディングにとって不利となる。下限値の－１を越えると、広角端での射出瞳が近すぎてシェーディングが発生しやすい点、第３レンズ群にてフォーカスをする際にその移動量が大きくなりすぎてスペース上の不利がある。また、近軸的に軸上光線高の高い第２レンズ群の像側の正レンズを強くする必要があるため、第２レンズ群の主点位置が後ろへ移動し、高い倍率を得難く、第１レンズ群が巨大化しやすい。

【００５３】条件（９）の下限の０．０２を越えると、非点収差の補正と広角端での射出瞳位置の関係でシェーディングが発生しやすい。上限の０．５を越えると、第２レンズ群の厚みが厚く、沈胴厚の小さくするのに足枷となる。

【００５４】なお、第2 レンズ群の正レンズＬ２１と負レンズＬ２２をひとまとめにした部分群と正レンズＬ２

３と負レンズL２４をひとまとめにした部分群との相対位置誤差の性能劣化に対する効きは小さい（ただし、その場合は正レンズL２３の非球面量は小さめにするのが望ましい。）ので、変倍時や撮像時には一定の間隔あるいは変化する間隔を大きめに設け、沈胴時にのみ縮める構造にしてもよい。d_{22}を撮像時に大きめにすることは、周辺部の性能確保に有利である。

【００５５】なお、条件（８）、（９）の何れかあるいは両方を以下のようにするとよりよい。

【００５６】

（８）’　$-0.7 < f_3 / f_{2R} < 1.0$

（９）’　$0.04 < d_{22} / L < 0.4$

さらに、条件（８）、（９）の何れかあるいは両方を以下のようにするとさらによい。特に両方を以下のようにすると最もよい。

【００５７】

（８）”　$-0.4 < f_3 / f_{2R} < 0.4$

（９）”　$0.06 < d_{22} / L < 0.3$

これとは別に、条件（２）又は（５）に対し、さらに以下の条件を満足すると沈胴時の小型化に有利である。

【００５８】(10)　$-1 < f_{2F} / R_{21R} < 2.5$

ただし、R_{21R}は第２レンズ群の正レンズL２１の像側の面の曲率半径、f_{2F}は第２レンズ群の正レンズL２１と負レンズL２２との合成焦点距離である。

【００５９】条件（１０）の上限の２．５を越えると、第２レンズ群の正レンズL２１と負レンズL２２のトータルの厚みを薄くしやすいが、軸上色収差の補正が困難になる。下限値の－１を越えると、軸上色収差の補正には有利だが、第２レンズ群の正レンズL２１と負レンズL２２のトータルの厚みを厚くせざるを得ず、沈胴厚を薄くするのに足枷となる。

【００６０】なお、以下のようにするとよりよい。

【００６１】

(10)’　$-0.8 < f_{2F} / R_{21R} < 0.8$

さらに、以下のようにすると最もよい。

【００６２】

(10)”　$-0.6 < f_{2F} / R_{21R} < 0.5$

前記条件（２）系又は（７）系又は（１０）系に対し、さらに以下の条件を満足すると、沈胴時の小型化に有利である。

【００６３】(11)　$-0.5 < f_2 / f_{2R} < 1$

ただし、f_2は第２レンズ群全体の合成焦点距離、f_{2R}は第２レンズ群の正レンズL２３と負レンズL２４との合成焦点距離である。

【００６４】条件（１１）は第２レンズ群の正レンズL２３と負レンズL２４との合成焦点距離と第２レンズ群全体の合成焦点距離の比を規定したものである。上限の１を越えると、第２レンズ群の主点が像側寄りになるために第２レンズ群倍率を高くならず、第１レンズ群の移動量が大きくなったり大型化しやすいか、使用状態における第２レンズ群後方にデッドスペースができやすく、全長が長くなり、沈胴厚を薄くするために鏡枠機械構造が複雑になるか巨大化する。あるいは、あまり薄くできない。下限値の－０．５を越えると、非点収差の補正が困難となる。

【００６５】なお、以下のようにするとよりよい。

【００６６】

(11)’　$-0.4 < f_2 / f_{2R} < 0.7$

さらに、以下のようにすると最もよい。

【００６７】

(11)”　$-0.3 < f_2 / f_{2R} < 0.4$

また、第３レンズ群については、全てのレンズ面共略球面より構成するのがよいが、その際、形状的に以下の条件を満たすのがよい。

【００６８】

$$(12)\quad -1.0 < (R_{31} + R_{32}) / (R_{31} - R_{32}) < 1.2$$

ただし、R_{31}とR_{32}はそれぞれ第３レンズ群の正レンズの最も物体側と最も像側の面の曲率半径である。

【００６９】条件（１２）の上限値の１．２を越えると、リアフォーカスによる非点収差の変動が大きくなりすぎ、無限物点で非点収差を良好に補正し得ても、近距離物点に対しては非点収差が悪化しやすい。下限値の－１．０を越えると、リアフォーカスによる非点収差変動は少ないが、無限物点に対する収差補正が困難となる。

【００７０】なお、以下のようにするとよりよい。

【００７１】

$$(12)'\quad -0.3 < (R_{31} + R_{32}) / (R_{31} - R_{32}) < 1.2$$

さらに、以下のようにすると最もよい。

【００７２】

$$(12)''\quad 0.0 < (R_{31} + R_{32}) / (R_{31} - R_{32}) < 1.0$$

以上、ズームレンズ部について沈胴厚を薄くしつつも、結像性能を良好にする手段を提供した。

【００７３】なお、本発明のズームレンズは、広角域を含む電子撮像装置を構成する上で有利である。特に、広角端における対角方向の半画角ω_Wが以下の条件を満足する電子撮像装置に用いることが好ましい（後記の各実施例に記載の広角端半画角はω_Wに相当する。）。

【００７４】$27° < \omega_W < 42°$　この条件の下限値の２７°を越えて広角端半画角が狭くなると、収差補正上は有利になるが、実用的な広角端での画角ではなくなる。一方、上限値の４２°を越えると、歪曲収差、倍率の色収差が発生しやすくなり、レンズ枚数が増加する。

【００７５】次に、フィルター類を薄くする件について言及する。電子撮像装置には、通常、赤外光が撮像面に入射しないように一定の厚みのある赤外吸収フィルターを撮像素子よりも物体側に挿入している。これを厚みの

ないコーティングに置き換えることを考える。当然その分薄くなる訳だが、副次的効果がある。ズームレンズ系後方にある撮像素子よりも物体側に、波長６００ｎｍでの透過率（τ_{600}）が８０％以上、７００ｎｍでの透過率（τ_{700}）が８％以下の近赤外シャープカットコートを導入すると、吸収タイプよりも７００ｎｍ以上の近赤外領域の透過率が低く、かつ、相対的に赤側の透過率が高くなり、補色モザイクフィルターを有するＣＣＤ等の固体撮像素子の欠点である青紫側のマゼンタ化傾向がゲイン調整により緩和され、原色フィルターを有するＣＣＤ等の固体撮像素子並みの色再現を得ることができる。

【００７６】すなわち、

(13)　　$\tau_{600}/\tau_{550} \geqq 0.8$

(14)　　$\tau_{700}/\tau_{550} \leqq 0.08$

を満たすことが望ましい。ただし、τ_{550}は波長５５０ｎｍでの透過率である。

【００７７】なお、条件（１３）、（１４）の何れかあるいは両方を以下のようにするとよりよい。

【００７８】(13)'　　$\tau_{600}/\tau_{550} \geqq 0.85$

(14)'　　$\tau_{700}/\tau_{550} \leqq 0.05$

さらに、条件（１３）、（１４）の何れかあるいは両方を以下のようにするとさらによい。特に両方を以下のようにすると最もよい。

【００７９】(13)"　　$\tau_{600}/\tau_{550} \geqq 0.9$

(14)"　　$\tau_{700}/\tau_{550} \leqq 0.03$

ＣＣＤ等の固体撮像素子のもう１つの欠点は、近紫外域の波長５５０ｎｍに対する感度が人間の眼のそれよりもかなり高いことである。これも、近紫外域の色収差による画像のエッジ部の色にじみを目立たせている。特に光学系を小型化すると致命的である。したがって、波長４００ｎｍでの透過率（τ_{400}）の５５０ｎｍでのそれ（τ_{550}）に対する比が０．０８を下回り、４４０ｎｍでの透過率（τ_{440}）の５５０ｎｍでのそれ（τ_{550}）に対する比が０．４を上回るような吸収体あるいは反射体を光路上に挿入すれば、色再現上必要な波長域を失わず（良好な色再現を保ったまま）、色にじみなどのノイズがかなり軽減される。

【００８０】すなわち、

(15)　　$\tau_{400}/\tau_{550} \leqq 0.08$

(16)　　$\tau_{440}/\tau_{550} \geqq 0.4$

を満たすことが望ましい。

【００８１】なお、条件（１５）、（１６）の何れかあるいは両方を以下のようにするとよりよい。

【００８２】(15)'　　$\tau_{400}/\tau_{550} \leqq 0.06$

(16)'　　$\tau_{440}/\tau_{550} \geqq 0.5$

さらに、条件（１５）、（１６）の何れかあるいは両方を以下のようにするとさらによい。特に両方を以下のようにすると最もよい。

【００８３】(15)"　　$\tau_{400}/\tau_{550} \leqq 0.04$

(16)"　　$\tau_{440}/\tau_{550} \geqq 0.6$

なお、これらのフィルターの設置場所は結像光学系と撮像素子の間がよい。

【００８４】一方、補色フィルターの場合、その透過光エネルギーの高さから、原色フィルター付きＣＣＤと比べ実質的感度が高く、かつ、解像的にも有利であるため、小型ＣＣＤを使用したときのメリットが大である。もう一方のフィルターである光学的ローパスフィルターについても、その総厚t_{LPF}（ｍｍ）が以下の条件を満たすようにするとよい。

【００８５】

(17)　　$0.15 < t_{LPF}/a < 0.45$

ただし、ａは撮像素子の水平画素ピッチ（単位μｍ）であり、５μｍ以下である。

【００８６】沈胴厚を薄くするには、光学的ローパスフィルターを薄くすることも効果的であるが、一般的にはモアレ抑制効果が減少して好ましくない。一方、画素ピッチが小さくなるにつれて結像レンズ系の回折の影響により、ナイキスト限界以上の周波数成分のコントラストは減少し、モアレ抑制効果の現象はある程度許容されるようになる。例えば、像面上投影時の方位角度が水平（＝０°）と±４５°方向にそれぞれ結晶軸を有する３種類のフィルターを光軸方向に重ねて使用する場合、かなりモアレ抑制効果があることが知られている。この場合のフィルターが最も薄くなる仕様としては、水平にａμｍ、±４５°方向にそれぞれSQRT(1/2)＊ａμｍだけずらせるものが知られている。このときのフィルター厚は、凡そ［１＋２＊SQRT(1/2)］＊ａ／５．８８（ｍｍ）となる。ここで、ＳＱＲＴはスクエアルートであり平方根を意味する。これは、丁度ナイキスト限界に相当する周波数においてコントラストをゼロにする仕様である。これよりは数％乃至数十％程度薄くすると、ナイキスト限界に相当する周波数のコントラストが少し出てくるが、上記回折の影響で抑えるることが可能になる。

【００８７】上記以外のフィルター仕様、例えば２枚重ねあるいは１枚で実施する場合も含めて、条件（１７）を満足するのがよい。その上限値の０．４５を越えると、光学的ローパスフィルターが厚すぎ薄型化の妨げになる。下限値の０．１５を越えると、モアレ除去が不十分になる。ただし、これを実施する場合のａの条件は５μｍ以下である。

【００８８】ａが４μｍ以下なら、より回折の影響を受けやすいので

(17)'　　$0.13 < t_{LPF}/a < 0.42$

としてもよい。

【００８９】また、水平画素ピッチと重ねるローパスフィルターの枚数に応じて、以下のようにしてもよい。

【００９０】(17)"　　$0.3 < t_{LPF}/a < 0.4$

ただし、３枚重ねかつ４≦ａ＜５（μｍ）のとき、

$0.2 < t_{LPF}/a < 0.28$

ただし、２枚重ねかつ４≦ａ＜５（μｍ）のとき、

$0.1 < t_{LPF} / a < 0.16$
ただし、１枚のみかつ４≦ａ＜５（μｍ）のとき、
$0.25 < t_{LPF} / a < 0.37$
ただし、３枚重ねかつａ＜４（μｍ）のとき、
$0.16 < t_{LPF} / a < 0.25$
ただし、２枚重ねかつａ＜４（μｍ）のとき、
$0.08 < t_{LPF} / a < 0.14$
ただし、１枚のみかつａ＜４（μｍ）のとき。

【００９１】画素ピッチの小さな電子撮像素子を使用する場合、絞り込みによる回折効果の影響で画質が劣化する。したがって、開口サイズが固定の複数の開口を有し、その中の１つを第１レンズ群の最も像側のレンズ面と第３レンズ群の最も物体側のレンズ面の間の何れかの光路内に挿入でき、かつ、他の開口と交換可能とすることで像面照度の調節することができる電子撮像装置としておき、その複数の開口の中、一部の開口内に５５０ｎｍに対する透過率がそれぞれ異なり、かつ、８０％未満であるような媒体を有するようにして光量調節を行なうのがよい。あるいは、ａ（μｍ）／Ｆナンバー＜０．４となるようなＦ値に相当する光量になるように調節を実施する場合は、開口内に５５０ｎｍに対する透過率がそれぞれ異なりかつ８０％未満の媒体を有する電子撮像装置とするのがよい。例えば、開放値から上記条件の範囲外ではその媒体なしかあるいは５５０ｎｍに対する透過率が９１％以上のダミー媒質としておき、範囲内のときは回折の影響が出る程に開口絞り径を小さくするのではなく、ＮＤフィルターのようなもので光量調節するのがよい。

【００９２】また、その複数の開口をそれぞれ径をＦ値に反比例して小さくしたものにして揃えておき、ＮＤフィルターの代わりにそれぞれ周波数特性の異なる光学的ローパスフィルターを開口内に入れておくのでもよい。絞り込むにつれて回折劣化が大きくなるので、開口径が小さくなる程光学的ローパスフィルターの周波数特性を高く設定しておく。

【００９３】

【発明の実施の形態】以下、本発明の電子撮像装置に用いられるズームレンズの実施例１～１０について説明する。実施例１～１０の無限遠物点合焦時の広角端（ａ）、中間状態（ｂ）、望遠端（ｃ）でのレンズ断面図をそれぞれ図１～図１０に示す。各図中、第１レンズ群はＧ１、絞りはＳ、第２レンズ群はＧ２、第３レンズ群はＧ３、赤外カット吸収フィルターはＩＦ、ローパスフィルターはＬＦ、電子撮像素子であるＣＣＤのカバーガラスはＣＧ、ＣＣＤの像面はＩで示してある。なお、赤外カット吸収フィルターＩＦに代えて、透明平板の入射面に近赤外シャープカットコートとしたものを用いてもよいし、ローパスフィルターＬＦに直接近赤外シャープカットコートを施してもよい。

【００９４】実施例１のズームレンズは、図１に示すように、両凹負レンズと、物体側に凸の正メニスカスレンズとからなる負屈折力の第１レンズ群Ｇ１、開口絞りＳ、両凸正レンズと両凹負レンズの接合レンズと、両凸正レンズと、物体側に凸の負メニスカスレンズとからなる正屈折力の第２レンズ群Ｇ２、両凸正レンズ１枚からなる正屈折力の第３レンズ群Ｇ３からなり、広角端から望遠端に変倍する際は、第１レンズ群Ｇ１は物体側に凹の軌跡を描いて移動し、望遠端では広角端より像面側の位置になり、第２レンズ群Ｇ２は開口絞りＳと一体に物体側に移動し、第３レンズ群Ｇ３は像面側に凸の軌跡を描いて移動し、望遠端では広角端より物体側の位置になる。近距離の被写体にフォーカシングするために、第３レンズ群Ｇ３は物体側に繰り出される。

【００９５】非球面は、第１レンズ群Ｇ１の両凹負レンズの像面側の面、第２レンズ群Ｇ２の接合レンズの物体側の面、両凸正レンズの物体側の面の３面に用いられている。

【００９６】実施例２のズームレンズは、図２に示すように、両凹負レンズと、両凸正レンズとからなる負屈折力の第１レンズ群Ｇ１、開口絞りＳ、物体側に凸の正メニスカスレンズと物体側に凸の負メニスカスレンズの接合レンズと、両凸正レンズと、平凹負レンズとからなる正屈折力の第２レンズ群Ｇ２、両凸正レンズ１枚からなる正屈折力の第３レンズ群Ｇ３からなり、広角端から望遠端に変倍する際は、第１レンズ群Ｇ１は物体側に凹の軌跡を描いて移動し、望遠端と広角端では略同じ位置になり、第２レンズ群Ｇ２は開口絞りＳと一体に物体側に移動し、第３レンズ群Ｇ３は像面側に移動する。近距離の被写体にフォーカシングするために、第３レンズ群Ｇ３は物体側に繰り出される。

【００９７】非球面は、第１レンズ群Ｇ１の両凹負レンズの像面側の面、第２レンズ群Ｇ２の接合レンズの物体側の面、両凸正レンズの物体側の面の３面に用いられている。

【００９８】実施例３のズームレンズは、図３に示すように、両凹負レンズと、物体側に凸の正メニスカスレンズとからなる負屈折力の第１レンズ群Ｇ１、開口絞りＳ、物体側に凸の正メニスカスレンズと物体側に凸の負メニスカスレンズの接合レンズと、両凸正レンズと、物体側に凸の負メニスカスレンズとからなる正屈折力の第２レンズ群Ｇ２、両凸正レンズ１枚からなる正屈折力の第３レンズ群Ｇ３からなり、広角端から望遠端に変倍する際は、第１レンズ群Ｇ１は物体側に凹の軌跡を描いて移動し、望遠端と広角端では略同じ位置になり、第２レンズ群Ｇ２は開口絞りＳと一体に物体側に移動し、第３レンズ群Ｇ３は固定である。近距離の被写体にフォーカシングするために、第３レンズ群Ｇ３は物体側に繰り出される。

【００９９】非球面は、第１レンズ群Ｇ１の両凹負レンズの像面側の面、第２レンズ群Ｇ２の接合レンズの物体

側の面、両凸正レンズの物体側の面の３面に用いられている。

【０１００】実施例４のズームレンズは、図４に示すように、物体側に凸の負メニスカスレンズ２枚と、両凸正レンズとからなる負屈折力の第１レンズ群Ｇ１、開口絞りＳ、物体側に凸の正メニスカスレンズと物体側に凸の負メニスカスレンズの接合レンズと、両凸正レンズと、物体側に凸の負メニスカスレンズとからなる正屈折力の第２レンズ群Ｇ２、両凸正レンズ１枚からなる正屈折力の第３レンズ群Ｇ３からなり、広角端から望遠端に変倍する際は、第１レンズ群Ｇ１は物体側に凹の軌跡を描いて移動し、望遠端では広角端より像面側の位置になり、第２レンズ群Ｇ２は開口絞りＳと一体に物体側に移動し、第３レンズ群Ｇ３は物体側に凸の軌跡を描いて移動し、望遠端では広角端より物体側の位置になる。近距離の被写体にフォーカシングするために、第３レンズ群Ｇ３は物体側に繰り出される。

【０１０１】非球面は、第１レンズ群Ｇ１の物体側の負メニスカスレンズの像面側の面、第２レンズ群Ｇ２の接合レンズの物体側の面、両凸正レンズの物体側の面の３面に用いられている。

【０１０２】実施例５のズームレンズは、図５に示すように、物体側に凸の負メニスカスレンズと、物体側に凸の正メニスカスレンズとからなる負屈折力の第１レンズ群Ｇ１、開口絞りＳ、凸平正レンズと平凹負レンズの接合レンズと、両凸正レンズと、両凹負レンズとからなる正屈折力の第２レンズ群Ｇ２、両凸正レンズ１枚からなる正屈折力の第３レンズ群Ｇ３からなり、広角端から望遠端に変倍する際は、第１レンズ群Ｇ１は物体側に凹の軌跡を描いて移動し、望遠端では広角端より像面側の位置になり、第２レンズ群Ｇ２は開口絞りＳと一体に物体側に移動し、第３レンズ群Ｇ３は物体側に移動する。近距離の被写体にフォーカシングするために、第３レンズ群Ｇ３は物体側に繰り出される。

【０１０３】非球面は、第１レンズ群Ｇ１の負メニスカスレンズの像面側の面、第２レンズ群Ｇ２の接合レンズの物体側の面、両凸正レンズの物体側の面の３面に用いられている。

【０１０４】実施例６のズームレンズは、図６に示すように、両凹負レンズと、物体側に凸の正メニスカスレンズとからなる負屈折力の第１レンズ群Ｇ１、開口絞りＳ、両凸正レンズと両凹負レンズの接合レンズと、両凸正レンズと、両凹負レンズとからなる正屈折力の第２レンズ群Ｇ２、両凸正レンズ１枚からなる正屈折力の第３レンズ群Ｇ３からなり、広角端から望遠端に変倍する際は、第１レンズ群Ｇ１は物体側に凹の軌跡を描いて移動し、望遠端では広角端より像面側の位置になり、第２レンズ群Ｇ２は開口絞りＳと一体に物体側に移動し、第３レンズ群Ｇ３は物体側に凸の軌跡を描いて移動し、望遠端では広角端より像面側の位置になる。近距離の被写体にフォーカシングするために、第３レンズ群Ｇ３は物体側に繰り出される。

【０１０５】非球面は、第１レンズ群Ｇ１の両凹負レンズの像面側の面、第２レンズ群Ｇ２の接合レンズの物体側の面、両凸正レンズの物体側の面の３面に用いられている。

【０１０６】実施例７のズームレンズは、図７に示すように、両凹負レンズと、物体側に凸の正メニスカスレンズとからなる負屈折力の第１レンズ群Ｇ１、開口絞りＳ、両凸正レンズと両凹負レンズの接合レンズと、両凸正レンズと、両凹負レンズとからなる正屈折力の第２レンズ群Ｇ２、両凸正レンズ１枚からなる正屈折力の第３レンズ群Ｇ３からなり、広角端から望遠端に変倍する際は、第１レンズ群Ｇ１は物体側に凹の軌跡を描いて移動し、望遠端では広角端より物体側の位置になり、第２レンズ群Ｇ２は開口絞りＳと一体に物体側に移動し、第３レンズ群Ｇ３は物体側に凸の軌跡を描いて移動し、望遠端と広角端では同じ位置になる。近距離の被写体にフォーカシングするために、第３レンズ群Ｇ３は物体側に繰り出される。

【０１０７】非球面は、第１レンズ群Ｇ１の両凹負レンズの像面側の面、第２レンズ群Ｇ２の接合レンズの物体側の面、両凸正レンズの物体側の面の３面に用いられている。

【０１０８】実施例８のズームレンズは、図８に示すように、両凹負レンズと、物体側に凸の正メニスカスレンズとからなる負屈折力の第１レンズ群Ｇ１、開口絞りＳ、物体側に凸の正メニスカスレンズと物体側に凸の負メニスカスレンズの接合レンズと、両凸正レンズと、像面側に凸の負メニスカスレンズとからなる正屈折力の第２レンズ群Ｇ２、両凸正レンズ１枚からなる正屈折力の第３レンズ群Ｇ３からなり、広角端から望遠端に変倍する際は、第１レンズ群Ｇ１は物体側に凹の軌跡を描いて移動し、望遠端では広角端より物体側の位置になり、第２レンズ群Ｇ２は開口絞りＳと一体に物体側に移動し、第３レンズ群Ｇ３は像面側に凸の軌跡を描いて移動し、望遠端では広角端より像面側の位置になる。近距離の被写体にフォーカシングするために、第３レンズ群Ｇ３は物体側に繰り出される。

【０１０９】非球面は、第１レンズ群Ｇ１の両凹負レンズの像面側の面、第２レンズ群Ｇ２の接合レンズの物体側の面、両凸正レンズの物体側の面の３面に用いられている。

【０１１０】実施例９のズームレンズは、図９に示すように、物体側に凸の負メニスカスレンズと、物体側に凸の正メニスカスレンズとからなる負屈折力の第１レンズ群Ｇ１、開口絞りＳ、凸平正レンズと平凹負レンズの接合レンズと、両凸正レンズと、物体側に凸の負メニスカスレンズとからなる正屈折力の第２レンズ群Ｇ２、両凸正レンズ１枚からなる正屈折力の第３レンズ群Ｇ３から

なり、広角端から望遠端に変倍する際は、第１レンズ群Ｇ１は物体側に凹の軌跡を描いて移動し、望遠端では広角端より像面側の位置になり、第２レンズ群Ｇ２は開口絞りＳと一体に物体側に移動し、第３レンズ群Ｇ３は物体側に移動する。近距離の被写体にフォーカシングするために、第３レンズ群Ｇ３は物体側に繰り出される。

【０１１１】非球面は、第１レンズ群Ｇ１の負メニスカスレンズの像面側の面、第２レンズ群Ｇ２の接合レンズの物体側の面、両凸正レンズの像面側の面の３面に用いられている。

【０１１２】実施例１０のズームレンズは、図１０に示すように、物体側に凸の負メニスカスレンズと、物体側に凸の正メニスカスレンズとからなる負屈折力の第１レンズ群Ｇ１、開口絞りＳ、物体側に凸の正メニスカスレンズと物体側に凸の負メニスカスレンズの接合レンズと、像面側に凸の正メニスカスレンズと、像面側に凸の負メニスカスレンズとからなる正屈折力の第２レンズ群Ｇ２、両凸正レンズ１枚からなる正屈折力の第３レンズ群Ｇ３からなり、広角端から望遠端に変倍する際は、第１レンズ群Ｇ１は物体側に凹の軌跡を描いて移動し、望遠端では広角端より像面側の位置になり、第２レンズ群Ｇ２は開口絞りＳと一体に物体側に移動し、第３レンズ群Ｇ３は物体側に凸の軌跡を描いて移動し、望遠端では広角端より物体側の位置になる。近距離の被写体にフォーカシングするために、第３レンズ群Ｇ３は物体側に繰り出される。

【０１１３】非球面は、第１レンズ群Ｇ１の負メニスカスレンズの像面側の面、第２レンズ群Ｇ２の接合レンズの物体側の面、単独の正メニスカスレンズの像面側の面の３面に用いられている。

【０１１４】以下に、上記各実施例の数値データを示すが、記号は上記の外、ｆは全系焦点距離、ωは半画角、F_{NO}はＦナンバー、ＷＥは広角端、ＳＴは中間状態、ＴＥは望遠端、r_1、r_2 …は各レンズ面の曲率半径、d_1、d_2 …は各レンズ面間の間隔、n_{d1}、n_{d2}…は各レンズのｄ線の屈折率、ν_{d1}、ν_{d2}…は各レンズのアッベ数である。なお、非球面形状は、ｘを光の進行方向を正とした光軸とし、ｙを光軸と直交する方向にとると、下記の式にて表される。

【０１１５】$x=(y^2/r)/[1+\{1-(K+1)(y/r)^2\}^{1/2}]+A_4y^4+A_6y^6+A_8y^8+A_{10}y^{10}$

ただし、ｒは近軸曲率半径、Ｋは円錐係数、A_4、A_6、A_8、A_{10} はそれぞれ４次、６次、８次、１０次の非球面係数である。

【０１１６】

実施例１

r_1 = −102.7129	d_1 = 0.7000	n_{d1} =1.80610	ν_{d1} =40.92
r_2 = 5.3602（非球面）	d_2 = 2.0000		
r_3 = 11.4378	d_3 = 1.8000	n_{d2} =1.84666	ν_{d2} =23.78
r_4 = 98.3090	d_4 = （可変）		
r_5 = ∞（絞り）	d_5 = 1.2000		
r_6 = 4.9724（非球面）	d_6 = 2.0000	n_{d3} =1.80610	ν_{d3} =40.92
r_7 = −64.0363	d_7 = 0.7000	n_{d4} =1.84666	ν_{d4} =23.78
r_8 = 7.0009	d_8 = 1.1549		
r_9 = 15.2680（非球面）	d_9 = 1.3000	n_{d5} =1.69350	ν_{d5} =53.21
r_{10}= −12.7034	d_{10}= 0.1500		
r_{11}= 91.7989	d_{11}= 0.7000	n_{d6} =1.80100	ν_{d6} =34.97
r_{12}= 8.2347	d_{12}= （可変）		
r_{13}= 11.7154	d_{13}= 1.8000	n_{d7} =1.48749	ν_{d7} =70.23
r_{14}= −20.5935	d_{14}= （可変）		
r_{15}= ∞	d_{15}= 0.8000	n_{d8} =1.51633	ν_{d8} =64.14
r_{16}= ∞	d_{16}= 1.5000	n_{d9} =1.54771	ν_{d9} =62.84
r_{17}= ∞	d_{17}= 0.8000		
r_{18}= ∞	d_{18}= 0.7500	n_{d10}=1.51633	ν_{d10}=64.14
r_{19}= ∞	d_{19}= 1.2097		
r_{20}= ∞（像面）			

非球面係数

第２面

Ｋ ＝ 0

A_4 =−9.1908 ×10^{-4}

A_6 = 1.0097 ×10^{-5}

A_8 =−1.5014 ×10^{-6}

A_{10}= 0.0000
第６面
K = 0
A_4 =-1.4735×10^{-4}
A_6 = 1.6281×10^{-5}
A_8 =-7.9774×10^{-7}
A_{10}= 0.0000
第９面
K = 0
A_4 =-2.0216×10^{-3}
A_6 =-1.8880×10^{-4}
A_8 = 9.7090×10^{-6}
A_{10}= 0.0000

ズームデータ（∞）

	WE	ST	TE
f （mm）	4.50523	8.68872	12.89933
F_{NO}	2.6065	3.5812	4.3925
ω （°）	33.2	18.1	12.4
d_4	15.98285	5.88144	1.50000
d_{12}	2.53628	8.66957	13.53479
d_{14}	0.92173	0.42989	0.99810

。

【０１１７】

実施例２

r_1 = −40.0207	d_1 = 0.7000	n_{d1} =1.80610	ν_{d1} =40.92
r_2 = 4.8393（非球面）	d_2 = 2.7104		
r_3 = 14.6390	d_3 = 1.5606	n_{d2} =1.84666	ν_{d2} =23.78
r_4 = −100.9877	d_4 = （可変）		
r_5 = ∞（絞り）	d_5 = 1.2000		
r_6 = 4.5526（非球面）	d_6 = 1.8758	n_{d3} =1.80610	ν_{d3} =40.92
r_7 = 15.8025	d_7 = 0.9429	n_{d4} =1.84666	ν_{d4} =23.78
r_8 = 4.0750	d_8 = 0.6028		
r_9 = 7.1659（非球面）	d_9 = 1.8221	n_{d5} =1.69350	ν_{d5} =53.21
r_{10}= −8.0623	d_{10}= 0.1000		
r_{11}= ∞	d_{11}= 1.0000	n_{d6} =1.80100	ν_{d6} =34.97
r_{12}= 6.7380	d_{12}= （可変）		
r_{13}= 13.4670	d_{13}= 1.6540	n_{d7} =1.48749	ν_{d7} =70.23
r_{14}= −21.9112	d_{14}= （可変）		
r_{15}= ∞	d_{15}= 0.8000	n_{d8} =1.51633	ν_{d8} =64.14
r_{16}= ∞	d_{16}= 1.5000	n_{d9} =1.54771	ν_{d9} =62.84
r_{17}= ∞	d_{17}= 0.8000		
r_{18}= ∞	d_{18}= 0.7500	n_{d10}=1.51633	ν_{d10}=64.14
r_{19}= ∞	d_{19}= 1.2000		
r_{20}= ∞（像面）			

非球面係数
第２面
K = 0
A_4 =-1.6364×10^{-3}
A_6 = 1.1356×10^{-5}
A_8 =-2.5627×10^{-6}
A_{10}= 0.0000

第６面

$K = 0$

$A_4 = -3.9899 \times 10^{-4}$

$A_6 = -2.2843 \times 10^{-5}$

$A_8 = -1.2585 \times 10^{-6}$

$A_{10} = -9.0236 \times 10^{-9}$

第９面

$K = 0$

$A_4 = -1.7288 \times 10^{-3}$

$A_6 = 4.6545 \times 10^{-5}$

$A_8 = -3.7671 \times 10^{-6}$

$A_{10} = 3.6071 \times 10^{-7}$

ズームデータ（∞）

	WE	ST	TE
f （mm）	4.20000	8.59999	12.80032
F_{NO}	2.4980	3.5636	4.6676
ω（°）	35.2	18.3	12.4
d_4	14.39292	4.31686	1.50000
d_{12}	1.90425	8.66884	15.45557
d_{14}	1.56049	1.52138	0.90000

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【０１１８】

実施例３

$r_1 =$ −41.7871	$d_1 =$ 0.7000	$n_{d1} =$ 1.80610	$\nu_{d1} =$ 40.92
$r_2 =$ 4.8061（非球面）	$d_2 =$ 2.1538		
$r_3 =$ 11.7830	$d_3 =$ 1.5885	$n_{d2} =$ 1.84666	$\nu_{d2} =$ 23.78
$r_4 =$ 498.8711	$d_4 =$（可変）		
$r_5 =$ ∞（絞り）	$d_5 =$ 1.2000		
$r_6 =$ 4.4711（非球面）	$d_6 =$ 1.8148	$n_{d3} =$ 1.80610	$\nu_{d3} =$ 40.92
$r_7 =$ 16.1235	$d_7 =$ 0.8513	$n_{d4} =$ 1.84666	$\nu_{d4} =$ 23.78
$r_8 =$ 4.0848	$d_8 =$ 0.5201		
$r_9 =$ 6.1325（非球面）	$d_9 =$ 1.6063	$n_{d5} =$ 1.69350	$\nu_{d5} =$ 53.21
$r_{10} =$ −11.1687	$d_{10} =$ 0.1000		
$r_{11} =$ 16.3851	$d_{11} =$ 1.0000	$n_{d6} =$ 1.80100	$\nu_{d6} =$ 34.97
$r_{12} =$ 4.8782	$d_{12} =$（可変）		
$r_{13} =$ 17.5725	$d_{13} =$ 1.7579	$n_{d7} =$ 1.48749	$\nu_{d7} =$ 70.23
$r_{14} =$ −13.0293	$d_{14} =$ 0.9000		
$r_{15} =$ ∞	$d_{15} =$ 0.8000	$n_{d8} =$ 1.51633	$\nu_{d8} =$ 64.14
$r_{16} =$ ∞	$d_{16} =$ 1.5000	$n_{d9} =$ 1.54771	$\nu_{d9} =$ 62.84
$r_{17} =$ ∞	$d_{17} =$ 0.8000		
$r_{18} =$ ∞	$d_{18} =$ 0.7500	$n_{d10} =$ 1.51633	$\nu_{d10} =$ 64.14
$r_{19} =$ ∞	$d_{19} =$ 1.2001		
$r_{20} =$ ∞（像面）			

非球面係数

第２面

$K = 0$

$A_4 = -1.5240 \times 10^{-3}$

$A_6 = 7.1028 \times 10^{-6}$

$A_8 = -2.5635 \times 10^{-6}$

$A_{10} = 0.0000$

第６面

$K=0$
$A_4=-4.1354\times10^{-4}$
$A_6=-2.4486\times10^{-5}$
$A_8=-1.4312\times10^{-6}$
$A_{10}=3.7941\times10^{-8}$
第９面
$K=0$
$A_4=-1.7166\times10^{-3}$
$A_6=5.3328\times10^{-5}$
$A_8=-4.9514\times10^{-6}$
$A_{10}=-5.3554\times10^{-8}$

ズームデータ（∞）

	WE	ST	TE
f (mm)	4.20005	8.60008	12.80003
F_{NO}	2.6418	3.7743	4.8647
ω (°)	35.2	18.3	12.5
d_4	13.62386	4.39163	1.50000
d_{12}	2.13358	8.33646	14.25744

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【０１１９】

実施例４

$r_1=$ 27.0909	$d_1=$ 0.7000	$n_{d1}=1.80610$	$\nu_{d1}=40.92$
$r_2=$ 6.6293（非球面）	$d_2=$ 1.8000		
$r_3=$ 144.3405	$d_3=$ 0.7000	$n_{d2}=1.80100$	$\nu_{d2}=34.97$
$r_4=$ 8.3285	$d_4=$ 0.8000		
$r_5=$ 9.3403	$d_5=$ 1.8000	$n_{d3}=1.80518$	$\nu_{d3}=25.42$
$r_6=$ −172.3059	$d_6=$（可変）		
$r_7=$ ∞（絞り）	$d_7=$ 1.2000		
$r_8=$ 4.6685（非球面）	$d_8=$ 2.0000	$n_{d4}=1.80610$	$\nu_{d4}=40.92$
$r_9=$ 39.3390	$d_9=$ 0.7000	$n_{d5}=1.84666$	$\nu_{d5}=23.78$
$r_{10}=$ 6.3668	$d_{10}=$ 1.0180		
$r_{11}=$ 21.8104（非球面）	$d_{11}=$ 1.3000	$n_{d6}=1.69350$	$\nu_{d6}=53.21$
$r_{12}=$ −13.5364	$d_{12}=$ 0.1500		
$r_{13}=$ 38.5671	$d_{13}=$ 0.7000	$n_{d7}=1.80518$	$\nu_{d7}=25.42$
$r_{14}=$ 8.0481	$d_{14}=$（可変）		
$r_{15}=$ 9.5072	$d_{15}=$ 1.8000	$n_{d8}=1.48749$	$\nu_{d8}=70.23$
$r_{16}=$ −24.4883	$d_{16}=$（可変）		
$r_{17}=$ ∞	$d_{17}=$ 0.8000	$n_{d9}=1.51633$	$\nu_{d9}=64.14$
$r_{18}=$ ∞	$d_{18}=$ 1.5000	$n_{d10}=1.54771$	$\nu_{d10}=62.84$
$r_{19}=$ ∞	$d_{19}=$ 0.8000		
$r_{20}=$ ∞	$d_{20}=$ 0.7500	$n_{d11}=1.51633$	$\nu_{d11}=64.14$
$r_{21}=$ ∞	$d_{21}=$ 1.2108		
$r_{22}=$ ∞（像面）			

非球面係数
第２面
$K=0$
$A_4=-2.9630\times10^{-4}$
$A_6=4.2847\times10^{-6}$
$A_8=-3.6003\times10^{-7}$
$A_{10}=0.0000$
第８面

$K = 0$

$A_4 = -2.6881 \times 10^{-4}$

$A_6 = 2.5560 \times 10^{-5}$

$A_8 = -3.5822 \times 10^{-7}$

$A_{10} = 0.0000$

第１１面

$K = 0$

$A_4 = -2.1333 \times 10^{-3}$

$A_6 = -2.4378 \times 10^{-4}$

$A_8 = 3.2564 \times 10^{-7}$

$A_{10} = 0.0000$

ズームデータ（∞）

	WE	ST	TE
f (mm)	4.48846	8.69183	12.90297
F_{NO}	2.5989	3.4016	4.5450
ω (°)	33.4	18.4	12.5
d_6	14.80359	3.81650	1.50000
d_{14}	2.53628	7.33575	14.91963
d_{16}	0.92173	1.86494	0.99412

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【０１２０】

実施例５

$r_1 =$ 208.2759	$d_1 =$ 0.7000	$n_{d1} = 1.74320$	$\nu_{d1} = 49.34$
$r_2 =$ 4.6930（非球面）	$d_2 =$ 2.0000		
$r_3 =$ 8.5950	$d_3 =$ 1.8000	$n_{d2} = 1.80518$	$\nu_{d2} = 25.42$
$r_4 =$ 20.6048	$d_4 =$（可変）		
$r_5 =$ ∞（絞り）	$d_5 =$ 1.2000		
$r_6 =$ 4.2440（非球面）	$d_6 =$ 2.0000	$n_{d3} = 1.80610$	$\nu_{d3} = 40.92$
$r_7 =$ ∞	$d_7 =$ 0.7000	$n_{d4} = 1.84666$	$\nu_{d4} = 23.78$
$r_8 =$ 5.0693	$d_8 =$ 0.6000		
$r_9 =$ 24.7066（非球面）	$d_9 =$ 1.3000	$n_{d5} = 1.69350$	$\nu_{d5} = 53.21$
$r_{10} =$ −10.1759	$d_{10} =$ 0.1500		
$r_{11} =$ −266.8373	$d_{11} =$ 0.7000	$n_{d6} = 1.80100$	$\nu_{d6} = 34.97$
$r_{12} =$ 14.0737	$d_{12} =$（可変）		
$r_{13} =$ 20.4220	$d_{13} =$ 1.8000	$n_{d7} = 1.48749$	$\nu_{d7} = 70.23$
$r_{14} =$ −14.3628	$d_{14} =$（可変）		
$r_{15} =$ ∞	$d_{15} =$ 0.8000	$n_{d8} = 1.51633$	$\nu_{d8} = 64.14$
$r_{16} =$ ∞	$d_{16} =$ 1.5000	$n_{d9} = 1.54771$	$\nu_{d9} = 62.84$
$r_{17} =$ ∞	$d_{17} =$ 0.8000		
$r_{18} =$ ∞	$d_{18} =$ 0.7500	$n_{d10} = 1.51633$	$\nu_{d10} = 64.14$
$r_{19} =$ ∞	$d_{19} =$ 1.2092		
$r_{20} =$ ∞（像面）			

非球面係数

第２面

$K = 0$

$A_4 = -1.1214 \times 10^{-3}$

$A_6 = 3.1893 \times 10^{-5}$

$A_8 = -4.1833 \times 10^{-6}$

$A_{10} = 0.0000$

第６面

$K = 0$

A_4 =-1.7255×10^{-5}
A_6 =-4.4178×10^{-5}
A_8 = 9.1087×10^{-6}
A_{10}= 0.0000
第９面
K = 0
A_4 =-3.5926×10^{-3}
A_6 =-7.1592×10^{-5}
A_8 =-6.8024×10^{-5}
A_{10}= 0.0000

ズームデータ（∞）

	WE	ST	TE
f (mm)	4.52199	8.69159	12.89618
F_{NO}	2.6728	3.5913	4.5324
ω (°)	33.2	18.1	12.4
d_4	13.53589	4.62823	1.50000
d_{12}	2.53628	7.65616	12.90171
d_{14}	0.92173	0.98067	1.00178 。

【０１２１】

実施例６

r_1 = −115.4675	d_1 = 0.7000	n_{d1} =1.80610	ν_{d1} =40.92
r_2 = 5.0884（非球面）	d_2 = 2.4077		
r_3 = 11.8048	d_3 = 1.5055	n_{d2} =1.84666	ν_{d2} =23.78
r_4 = 79.1966	d_4 = （可変）		
r_5 = ∞（絞り）	d_5 = 1.2000		
r_6 = 4.9875（非球面）	d_6 = 2.2097	n_{d3} =1.80610	ν_{d3} =40.92
r_7 = −92.9504	d_7 = 0.7000	n_{d4} =1.84666	ν_{d4} =23.78
r_8 = 7.0480	d_8 = 1.7157		
r_9 = 20.4501（非球面）	d_9 = 1.4488	n_{d5} =1.69350	ν_{d5} =53.21
r_{10}= −5.4179	d_{10}= 0.2153		
r_{11}= −6.0014	d_{11}= 1.0000	n_{d6} =1.80100	ν_{d6} =34.97
r_{12}= 56.3492	d_{12}= （可変）		
r_{13}= 12.4691	d_{13}= 1.6359	n_{d7} =1.48749	ν_{d7} =70.23
r_{14}= −24.0279	d_{14}= （可変）		
r_{15}= ∞	d_{15}= 0.8000	n_{d8} =1.51633	ν_{d8} =64.14
r_{16}= ∞	d_{16}= 1.5000	n_{d9} =1.54771	ν_{d9} =62.84
r_{17}= ∞	d_{17}= 0.8000		
r_{18}= ∞	d_{18}= 0.7500	n_{d10}=1.51633	ν_{d10}=64.14
r_{19}= ∞	d_{19}= 1.1985		
r_{20}= ∞（像面）			

非球面係数
第２面
K = 0
A_4 =-1.0638×10^{-3}
A_6 = 2.1512×10^{-6}
A_8 =-1.6979×10^{-6}
A_{10}= 0.0000
第６面
K = 0
A_4 =-2.6779×10^{-4}

$A_6 = 1.4102 \times 10^{-6}$
$A_8 = -8.0728 \times 10^{-7}$
$A_{10} = 0.0000$
第９面
$K = 0$
$A_4 = -2.1523 \times 10^{-3}$
$A_6 = -8.1365 \times 10^{-5}$
$A_8 = -5.0480 \times 10^{-6}$
$A_{10} = 0.0000$

ズームデータ（∞）

	WE	ST	TE
f (mm)	4.49939	8.59837	12.79887
F_{NO}	2.6057	3.4199	4.4288
ω (°)	33.2	18.4	12.5
d_4	14.90728	4.50456	1.50000
d_{12}	2.34564	7.26336	13.74810
d_{14}	0.95850	1.50353	0.90000

。

【０１２２】

実施例７

$r_1 = -552.0327$	$d_1 = 0.7000$	$n_{d1} = 1.80610$	$\nu_{d1} = 40.92$
$r_2 = 4.3477$（非球面）	$d_2 = 1.6776$		
$r_3 = 8.2917$	$d_3 = 1.5233$	$n_{d2} = 1.84666$	$\nu_{d2} = 23.78$
$r_4 = 25.4637$	$d_4 =$（可変）		
$r_5 = \infty$（絞り）	$d_5 = 1.2000$		
$r_6 = 4.7104$（非球面）	$d_6 = 1.9721$	$n_{d3} = 1.80610$	$\nu_{d3} = 40.92$
$r_7 = -33.7287$	$d_7 = 0.7000$	$n_{d4} = 1.84666$	$\nu_{d4} = 23.78$
$r_8 = 7.9668$	$d_8 = 1.9478$		
$r_9 = 22.3098$（非球面）	$d_9 = 1.3699$	$n_{d5} = 1.69350$	$\nu_{d5} = 53.21$
$r_{10} = -5.5074$	$d_{10} = 0.1000$		
$r_{11} = -6.0325$	$d_{11} = 1.0000$	$n_{d6} = 1.80100$	$\nu_{d6} = 34.97$
$r_{12} = 52.7538$	$d_{12} =$（可変）		
$r_{13} = 15.2026$	$d_{13} = 1.7414$	$n_{d7} = 1.48749$	$\nu_{d7} = 70.23$
$r_{14} = -14.4840$	$d_{14} =$（可変）		
$r_{15} = \infty$	$d_{15} = 0.8000$	$n_{d8} = 1.51633$	$\nu_{d8} = 64.14$
$r_{16} = \infty$	$d_{16} = 1.5000$	$n_{d9} = 1.54771$	$\nu_{d9} = 62.84$
$r_{17} = \infty$	$d_{17} = 0.8000$		
$r_{18} = \infty$	$d_{18} = 0.7500$	$n_{d10} = 1.51633$	$\nu_{d10} = 64.14$
$r_{19} = \infty$	$d_{19} = 1.2000$		
$r_{20} = \infty$（像面）			

非球面係数
第２面
$K = 0$
$A_4 = -1.4967 \times 10^{-3}$
$A_6 = 1.2766 \times 10^{-5}$
$A_8 = -5.5780 \times 10^{-6}$
$A_{10} = 0.0000$
第６面
$K = 0$
$A_4 = -3.4707 \times 10^{-4}$
$A_6 = 2.7502 \times 10^{-6}$

A_8 =−8.5549 ×10^{-7}
A_{10}= 0.0000
第９面
K = 0
A_4 =−2.6615 ×10^{-3}
A_6 =−9.6885 ×10^{-5}
A_8 =−1.1909 ×10^{-5}
A_{10}= 0.0000

ズームデータ（∞）

	WE	ST	TE
f (mm)	4.50002	8.89986	12.79811
F_{NO}	2.6022	3.5568	4.6259
ω (°)	33.1	17.8	12.6
d_4	10.91791	3.18224	1.50000
d_{12}	1.70000	7.41371	14.11791
d_{14}	0.90000	1.65812	0.90000

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【０１２３】

実施例８

r_1 = −34.8037	d_1 = 0.7000	n_{d1} =1.80610	ν_{d1} =40.92
r_2 = 4.1900（非球面）	d_2 = 1.1999		
r_3 = 8.0659	d_3 = 1.6447	n_{d2} =1.84666	ν_{d2} =23.78
r_4 = 48.7210	d_4 = （可変）		
r_5 = ∞（絞り）	d_5 = 1.2000		
r_6 = 3.8631（非球面）	d_6 = 1.7680	n_{d3} =1.80610	ν_{d3} =40.92
r_7 = 62.8242	d_7 = 0.7000	n_{d4} =1.84666	ν_{d4} =23.78
r_8 = 4.5969	d_8 = 2.3429		
r_9 = 13.0143（非球面）	d_9 = 1.4756	n_{d5} =1.69350	ν_{d5} =53.21
r_{10}= −7.3240	d_{10}= 0.1000		
r_{11}= −6.0586	d_{11}= 1.0000	n_{d6} =1.80100	ν_{d6} =34.97
r_{12}= −25.9560	d_{12}= （可変）		
r_{13}= 44.0311	d_{13}= 1.6462	n_{d7} =1.48749	ν_{d7} =70.23
r_{14}= −10.9953	d_{14}= （可変）		
r_{15}= ∞	d_{15}= 0.8000	n_{d8} =1.51633	ν_{d8} =64.14
r_{16}= ∞	d_{16}= 1.5000	n_{d9} =1.54771	ν_{d9} =62.84
r_{17}= ∞	d_{17}= 0.8000		
r_{18}= ∞	d_{18}= 0.7500	n_{d10}=1.51633	ν_{d10}=64.14
r_{19}= ∞	d_{19}= 1.1968		
r_{20}= ∞（像面）			

非球面係数
第２面
K = 0
A_4 =−2.0325 ×10^{-3}
A_6 =−5.3892 ×10^{-6}
A_8 =−6.1267 ×10^{-6}
A_{10}= 0.0000
第６面
K = 0
A_4 =−7.6210 ×10^{-4}
A_6 =−2.6462 ×10^{-5}
A_8 =−4.0575 ×10^{-6}

A_{10}=−1.4214 ×10^{-8}
第９面
K = 0
A_4 =−1.9457 ×10^{-3}
A_6 =−9.6412 ×10^{-5}
A_8 = 9.3922 ×10^{-7}
A_{10}=−3.1543 ×10^{-8}

ズームデータ（∞）

	WE	ST	TE
f (mm)	4.49848	8.59759	12.79866
F_{NO}	2.6659	3.7467	4.6171
ω (°)	33.2	18.5	12.7
d_4	10.65871	4.48879	1.50000
d_{12}	1.89640	8.96466	14.27271
d_{14}	1.11760	0.02771	0.90000

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【０１２４】

実施例９

r_1 = 354.9584	d_1 = 0.7000	n_{d1} =1.80610	ν_{d1} =40.92
r_2 = 4.6698（非球面）	d_2 = 2.0000		
r_3 = 9.2747	d_3 = 1.8000	n_{d2} =1.84666	ν_{d2} =23.78
r_4 = 29.2897	d_4 = （可変）		
r_5 = ∞（絞り）	d_5 = 1.2000		
r_6 = 4.7808（非球面）	d_6 = 2.0000	n_{d3} =1.80610	ν_{d3} =40.92
r_7 = −100.0000	d_7 = 0.7000	n_{d4} =1.84666	ν_{d4} =23.78
r_8 = 7.1229	d_8 = 0.9250		
r_9 = 11.1248	d_9 = 1.3000	n_{d5} =1.69350	ν_{d5} =53.21
r_{10}= −575.7637（非球面）	d_{10}= 0.1500		
r_{11}= 149.0119	d_{11}= 0.7000	n_{d6} =1.84666	ν_{d6} =23.78
r_{12}= 16.0252	d_{12}= （可変）		
r_{13}= 18.2359	d_{13}= 1.8000	n_{d7} =1.48749	ν_{d7} =70.23
r_{14}= −16.5835	d_{14}= （可変）		
r_{15}= ∞	d_{15}= 0.8000	n_{d8} =1.51633	ν_{d8} =64.14
r_{16}= ∞	d_{16}= 1.5000	n_{d9} =1.54771	ν_{d9} =62.84
r_{17}= ∞	d_{17}= 0.8000		
r_{18}= ∞	d_{18}= 0.7500	n_{d10}=1.51633	ν_{d10}=64.14
r_{19}= ∞	d_{19}= 1.2099		
r_{20}= ∞（像面）			

非球面係数
第２面
K = 0
A_4 =−1.1690 ×10^{-3}
A_6 = 1.7413 ×10^{-5}
A_8 =−3.7161 ×10^{-6}
A_{10}= 0.0000
第６面
K = 0
A_4 =−8.5856 ×10^{-5}
A_6 = 1.6399 ×10^{-6}
A_8 =−4.4906 ×10^{-8}
A_{10}= 0.0000

第１０面
K ＝ 0
A_4 = 3.0886 $\times 10^{-3}$
A_6 = 7.0935 $\times 10^{-5}$
A_8 = 2.3661 $\times 10^{-5}$
A_{10}= 0.0000

ズームデータ（∞）

	WE	ST	TE
f (mm)	4.50424	8.68935	12.89934
F_{NO}	2.6359	3.5740	4.5352
ω (°)	33.3	18.1	12.4
d_4	13.20936	4.52377	1.50000
d_{12}	2.53628	7.86108	13.31534
d_{14}	0.92173	0.98683	0.99884

。

【０１２５】

実施例１０

r_1 = 84.8334	d_1 = 0.7000	n_{d1} =1.74320	ν_{d1} =49.34
r_2 = 4.8594（非球面）	d_2 = 2.0000		
r_3 = 9.0964	d_3 = 1.8000	n_{d2} =1.84666	ν_{d2} =23.78
r_4 = 18.5606	d_4 = （可変）		
r_5 = ∞（絞り）	d_5 = 1.2000		
r_6 = 4.2563（非球面）	d_6 = 2.0000	n_{d3} =1.80610	ν_{d3} =40.92
r_7 = 100.0000	d_7 = 0.7000	n_{d4} =1.84666	ν_{d4} =23.78
r_8 = 6.3678	d_8 = 0.4000		
r_9 = -34.3924	d_9 = 1.3000	n_{d5} =1.69350	ν_{d5} =53.21
r_{10}= -8.0179（非球面）	d_{10}= 0.3000		
r_{11}= -8.3805	d_{11}= 0.7000	n_{d6} =1.84666	ν_{d6} =23.78
r_{12}= -21.0856	d_{12}= （可変）		
r_{13}= 14.6488	d_{13}= 1.8000	n_{d7} =1.48749	ν_{d7} =70.23
r_{14}= -20.2077	d_{14}= （可変）		
r_{15}= ∞	d_{15}= 0.8000	n_{d8} =1.51633	ν_{d8} =64.14
r_{16}= ∞	d_{16}= 1.5000	n_{d9} =1.54771	ν_{d9} =62.84
r_{17}= ∞	d_{17}= 0.8000		
r_{18}= ∞	d_{18}= 0.7500	n_{d10}=1.51633	ν_{d10}=64.14
r_{19}= ∞	d_{19}= 1.2068		
r_{20}= ∞（像面）			

非球面係数

第２面
K ＝ 0
A_4 =-1.0284 $\times 10^{-3}$
A_6 = 3.3497 $\times 10^{-5}$
A_8 =-3.4598 $\times 10^{-6}$
A_{10}= 0.0000

第６面
K ＝ 0
A_4 =-5.8749 $\times 10^{-5}$
A_6 =-9.9305 $\times 10^{-6}$
A_8 = 6.6151 $\times 10^{-6}$
A_{10}= 0.0000

第１０面

$K=0$
$A_4=3.5852\times10^{-3}$
$A_6=2.6012\times10^{-4}$
$A_8=4.5257\times10^{-5}$
$A_{10}=0.0000$

ズームデータ（∞）

	WE	ST	TE
f（mm）	4.51247	8.69085	12.90169
F_{NO}	2.7040	3.5173	4.5477
ω（°）	33.2	18.1	12.3
d_4	13.56120	4.06037	1.50000
d_{12}	2.53628	6.76140	13.02411
d_{14}	0.92173	1.69971	1.00981

。

【０１２６】以上の実施例１の無限遠物点合焦時及び被写体距離１０ｃｍ合焦時の収差図をそれぞれ図１１、図１２に示す。これらの収差図において、（ａ）は広角端、（ｂ）は中間状態、（ｃ）は望遠端における球面収差ＳＡ、非点収差ＡＳ、歪曲収差ＤＴ、倍率色収差ＣＣを示す。図中、“ＦＩＹ”は像高を表す。

【０１２７】なお、上記実施例中で開示した非球面について、その面の偏倚量の基準となる基準球面の曲率半径ｒはその面のr_a（ａは面番号）として示してある。

【０１２８】次に、上記各実施例における条件（１）～（５）、（７）～（１７）の値、条件（６）に関するAsp21F、Asp2R 及びＬの値を示す。

実施例	1	2	3	4	5
（１）	1.40795	0.89509	0.91360	1.36378	1.19446
（２）	0.50176	0.69462	0.84327	0.55884	0.52936
（３）	0.02679	0.01786	0.01786	0.02679	0.02679
（４）	0.10067	0.45293	0.48599	0.05301	0.21846
（５）	35.38000	35.38000	35.38000	44.93000	35.38000
（７）	−0.16942	0.05535	0.04515	−0.15390	−0.08862
（８）	0.28050	1.40535	1.35749	0.13534	0.68642
（９）	0.20624	0.10763	0.09287	0.18179	0.10714
(10)	−0.22380	2.21234	2.06386	0.34032	0.00000
(11)	0.20618	0.91029	0.89705	0.10983	0.39782
(12)	−0.27479	−0.23868	0.14846	−0.44068	0.17419
(13)	1.0	1.0	1.0	1.0	1.0
(14)	0.04	0.04	0.04	0.04	0.04
(15)	0.0	0.0	0.0	0.0	0.0
(16)	1.06	1.06	1.06	1.06	1.06
(17)	0.333	0.333	0.333	0.333	0.333
	(a=3.0)	(a=3.0)	(a=3.0)	(a=3.0)	(a=3.0)
Asp21F	−0.00086	−0.00377	−0.00393	−0.00055	−0.00159
Asp2R	−0.01973	−0.01290	−0.01280	−0.03454	−0.02245
L	5.6	5.6	5.6	5.6	5.6

。

実施例	6	7	8	9	10
（１）	1.4130	1.6913	1.1900	1.48990	1.49609
（２）	0.10050	0.08851	−0.02852	0.04735	0.03011
（３）	0.03845	0.01786	0.01786	0.02679	0.05357
（４）	0.11252	0.06773	0.26914	0.11434	0.04250
（５）	35.38000	35.38000	35.38000	46.57000	46.57000
（７）	−0.17120	−0.25687	−0.08674	−0.19676	−0.19874
（８）	0.34339	0.18764	0.87599	0.37005	0.13448
（９）	0.30638	0.34782	0.41838	0.16517	0.07143

(10)	-0.14892	-0.32727	0.20611	-0.12627	0.10616
(11)	0.22705	0.11962	0.46776	0.20849	0.07773
(12)	-0.31671	0.02420	0.60036	0.04746	-0.15948
(13)	1.0	1.0	1.0	1.0	1.0
(14)	0.04	0.04	0.04	0.04	0.04
(15)	0.0	0.0	0.0	0.0	0.0
(16)	1.06	1.06	1.06	1.06	1.06
(17)	0.333	0.333	0.333	0.333	0.333
	(a=3.0)	(a=3.0)	(a=3.0)	(a=3.0)	(a=3.0)
Asp21F	-0.00215	-0.00276	-0.00693	-0.00065	-0.00027
Asp2R	-0.01929	-0.02414	-0.01817	0.02770	0.03728
L	5.6	5.6	5.6	5.6	5.6

【０１２９】なお、実施例１～１０のローパスフィルターＬＦの総厚 t_{LPF} は何れも１．５００（ｍｍ）で３枚重ねで構成している。もちろん、上述の実施例は、例えばローパスフィルターＬＦを１枚で構成する等、前記した構成の範囲内で種々変更可能である。

【０１３０】ここで、有効撮像面の対角長Ｌと画素間隔ａについて説明しておく。図１４は、撮像素子の画素配列の１例を示す図であり、画素間隔ａでＲ（赤）、Ｇ（緑）、Ｂ（青）の画素あるいはシアン、マゼンダ、イエロー、グリーン（緑）の４色の画素（図１４）がモザイク状に配されている。有効撮像面は撮影した映像の再生（パソコン上での表示、プリンターによる印刷等）に用いる撮像素子上の光電変換面内における領域を意味する。図中に示す有効撮像面は、光学系の性能（光学系の性能が確保し得るイメージサークル）に合わせて、撮像素子の全光電変換面よりも狭い領域に設定されている。有効撮像面の対角長Ｌは、この有効撮像面の対角長である。なお、映像の再生に用いる撮像範囲を種々変更可能としてよいが、そのような機能を有する撮像装置に本発明のズームレンズを用いる際は、その有効撮像面の対角長Ｌが変化する。そのような場合は、本発明における有効撮像面の対角長Ｌは、Ｌのとり得る範囲における最大値とする。

【０１３１】また、赤外カット手段については、赤外カット吸収フィルターＩＦと赤外シャープカットコートとがあり、赤外カット吸収フィルターＩＦはガラス中に赤外吸収体が含有される場合で、赤外シャープカットコートは吸収でなく反射によるカットである。したがって、前記したように、この赤外カット吸収フィルターＩＦを除去して、ローパスフィルターＬＦに直接赤外シャープカットコートを施してもよいし、ダミー透明平板上に施してもよい。

【０１３２】この場合の近赤外シャープカットコートは、波長６００ｎｍでの透過率が８０％以上、波長７００ｎｍでの透過率が１０％以下となるように構成することが望ましい。具体的には、例えば次のような２７層の層構成からなる多層膜である。ただし、設計波長は７８０ｎｍである。

【０１３３】

基　板	材質	物理的膜厚（ｎｍ）	λ／４
第１層	Al_2O_3	５８．９６	０．５０
第２層	TiO_2	８４．１９	１．００
第３層	SiO_2	１３４．１４	１．００
第４層	TiO_2	８４．１９	１．００
第５層	SiO_2	１３４．１４	１．００
第６層	TiO_2	８４．１９	１．００
第７層	SiO_2	１３４．１４	１．００
第８層	TiO_2	８４．１９	１．００
第９層	SiO_2	１３４．１４	１．００
第10層	TiO_2	８４．１９	１．００
第11層	SiO_2	１３４．１４	１．００
第12層	TiO_2	８４．１９	１．００
第13層	SiO_2	１３４．１４	１．００
第14層	TiO_2	８４．１９	１．００
第15層	SiO_2	１７８．４１	１．３３

第16層	TiO_2	１０１．０３	１．２１
第17層	SiO_2	１６７．６７	１．２５
第18層	TiO_2	９６．８２	１．１５
第19層	SiO_2	１４７．５５	１．０５
第20層	TiO_2	８４．１９	１．００
第21層	SiO_2	１６０．９７	１．２０
第22層	TiO_2	８４．１９	１．００
第23層	SiO_2	１５４．２６	１．１５
第24層	TiO_2	９５．１３	１．１３
第25層	SiO_2	１６０．９７	１．２０
第26層	TiO_2	９９．３４	１．１８
第27層	SiO_2	８７．１９	０．６５

空　気

【０１３４】上記の近赤外シャープカットコートの透過率特性は図１５に示す通りである。

【０１３５】また、ローパスフィルターＬＦの射出面側には、図１６に示すような短波長域の色の透過を低減する色フィルターを設けるか若しくはコーティングを行うことで、より一層電子画像の色再現性を高めている。

【０１３６】具体的には、このフィルター若しくはコーティングにより、波長４００ｎｍ～７００ｎｍで透過率が最も高い波長の透過率に対する４２０ｎｍの波長の透過率の比が１５％以上であり、その最も高い波長の透過率に対する４００ｎｍの波長の透過率の比が６％以下であることが好ましい。

【０１３７】それにより、人間の目の色に対する認識と、撮像及び再生される画像の色とのずれを低減させることができる。言い換えると、人間の視覚では認識され難い短波長側の色が、人間の目で容易に認識されることによる画像の劣化を防止することができる。

【０１３８】上記の４００ｎｍの波長の透過率の比が６％を越えると、人間の目では認識され難い単波長城が認識し得る波長に再生されてしまい、逆に、上記の４２０ｎｍの波長の透過率の比が１５％よりも小さいと、人間の認識し得る波長城の再生が低くなり、色のバランスが悪くなる。

【０１３９】このような波長を制限する手段は、補色モザイクフィルターを用いた撮像系においてより効果を奏するものである。

【０１４０】上記各実施例では、図１６に示すように、波長４００ｎｍにおける透過率を０％、４２０ｎｍにおける透過率を９０％、４４０ｎｍにて透過率のピーク１００％となるコーティングとしている。

【０１４１】前記した近赤外シャープカットコートとの作用の掛け合わせにより、波長４５０ｎｍの透過率９９％をピークとして、４００ｎｍにおける透過率を０％、４２０ｎｍにおける透過率を８０％、６００ｎｍにおける透過率を８２％、７００ｎｍにおける透過率を２％としている。それにより、より忠実な色再現を行っている。

【０１４２】また、ローパスフィルターＬＦは、像面上投影時の方位角度が水平（＝０°）と±４５°方向にそれぞれ結晶軸を有する３種類のフィルターを光軸方向に重ねて使用しており、それぞれについて、水平にａμｍ、±４５°方向にそれぞれSQRT(1/2) ×ａだけずらすことで、モアレ抑制を行っている。ここで、ＳＱＲＴは前記のようにスクエアルートであり平方根を意味する。

【０１４３】また、ＣＣＤの撮像面Ｉ上には、図１７に示す通り、シアン、マゼンダ、イエロー、グリーン（緑）の４色の色フィルターを撮像画素に対応してモザイク状に設けた補色モザイクフィルターを設けている。これら４種類の色フィルターは、それぞれが略同じ数になるように、かつ、隣り合う画素が同じ種類の色フィルターに対応しないようにモザイク状に配置されている。それにより、より忠実な色再現が可能となる。

【０１４４】補色モザイクフィルターは、具体的には、図１７に示すように少なくとも４種類の色フィルターから構成され、その４種類の色フィルターの特性は以下の通りであることが好ましい。

【０１４５】グリーンの色フイルターＧは波長G_Pに分光強度のピークを有し、イエローの色フィルターY_eは波長Y_Pに分光強度のピークを有し、シアンの色フィルターＣは波長C_Pに分光強度のピークを有し、マゼンダの色フィルターＭは波長M_{P1}とM_{P2}にピークを有し、以下の条件を満足する。

【０１４６】$510\,\mathrm{nm} < G_P < 540\,\mathrm{nm}$

$5\,\mathrm{nm} < Y_P - G_P < 35\,\mathrm{nm}$

$-100\,\mathrm{nm} < C_P - G_P < -5\,\mathrm{nm}$

$430\,\mathrm{nm} < M_{P1} < 480\,\mathrm{nm}$

$580\,\mathrm{nm} < M_{P2} < 640\,\mathrm{nm}$

さらに、グリーン、イエロー、シアンの色フィルターはそれぞれの分光強度のピークに対して波長５３０ｎｍでは８０％以上の強度を有し、マゼンダの色フィルターはその分光強度のピークに対して波長５３０ｎｍでは１０％から５０％の強度を有することが、色再現性を高める

上でより好ましい。

【０１４７】上記各実施例におけるそれぞれの波長特性の一例を図１８に示す。グリーンの色フィルターＧは５２５ｎｍに分光強度のピークを有している。イエローの色フィルターY_eは５５５ｎｍに分光強度のピークを有している。シアンの色フイルターＣは５１０ｎｍに分光強度のピークを有している。マゼンダの色フィルターＭは４４５ｎｍと６２０ｎｍにピークを有している。また、５３０ｎｍにおける各色フィルターは、それぞれの分光強度のピークに対して、Ｇは９９％、Y_eは９５％、Ｃは９７％、Ｍは３８％としている。

【０１４８】このような補色フイルターの場合、図示しないコントローラー（若しくは、デジタルカメラに用いられるコントローラー）で、電気的に次のような信号処理を行い、

輝度信号

$Y = |G + M + Y_e + C| \times 1/4$

色信号

$R - Y = |(M + Y_e) - (G + C)|$

$B - Y = |(M + C) - (G + Y_e)|$

の信号処理を経てＲ（赤）、Ｇ（緑）、Ｂ（青）の信号に変換される。

【０１４９】ところで、上記した近赤外シャープカットコートの配置位置は、光路上のどの位置であってもよい。また、ローパスフィルターＬＦの枚数も前記した通り２枚でも１枚でも構わない。

【０１５０】さて、以上のような本発明の電子撮像装置は、ズームレンズで物体像を形成しその像をＣＣＤ等の電子撮像素子に受光させて撮影を行う撮影装置、とりわけデジタルカメラやビデオカメラ、情報処理装置の例であるパソコン、電話、特に持ち運びに便利な携帯電話等に用いることができる。以下に、その実施形態を例示する。

【０１５１】図１９～図２１は、本発明によるズームレンズをデジタルカメラの撮影光学系４１に組み込んだ構成の概念図を示す。図１９はデジタルカメラ４０の外観を示す前方斜視図、図２０は同後方斜視図、図２１はデジタルカメラ４０の構成を示す断面図である。デジタルカメラ４０は、この例の場合、撮影用光路４２を有する撮影光学系４１、ファインダー用光路４４を有するファインダー光学系４３、シャッター４５、フラッシュ４６、液晶表示モニター４７等を含み、カメラ４０の上部に配置されたシャッター４５を押圧すると、それに連動して撮影光学系４１、例えば実施例１のズームレンズを通して撮影が行われる。撮影光学系４１によって形成された物体像が、近赤外カットコートをダミー透明平板上に施してなる赤外カット吸収フィルターＩＦ、光学的ローパスフィルターＬＦを介してＣＣＤ４９の撮像面上に形成される。このＣＣＤ４９で受光された物体像は、処理手段５１を介し、電子画像としてカメラ背面に設けられた液晶表示モニター４７に表示される。また、この処理手段５１には記録手段５２が接続され、撮影された電子画像を記録することもできる。なお、この記録手段５２は処理手段５１と別体に設けてもよいし、フロッピー（登録商標）ディスクやメモリーカード、ＭＯ等により電子的に記録書込を行うように構成してもよい。また、ＣＣＤ４９に代わって銀塩フィルムを配置した銀塩カメラとして構成してもよい。

【０１５２】さらに、ファインダー用光路４４上にはファインダー用対物光学系５３が配置してある。このファインダー用対物光学系５３によって形成された物体像は、像正立部材であるポロプリズム５５の視野枠５７上に形成される。このポリプリズム５５の後方には、正立正像にされた像を観察者眼球Ｅに導く接眼光学系５９が配置されている。なお、撮影光学系４１及びファインダー用対物光学系５３の入射側、接眼光学系５９の射出側にそれぞれカバー部材５０が配置されている。

【０１５３】このように構成されたデジタルカメラ４０は、撮影光学系４１が広画角で高変倍比であり、収差が良好で、明るく、フィルター等が配置できるバックフォーカスの大きなズームレンズであるので、高性能・低コスト化が実現できる。

【０１５４】なお、図２１の例では、カバー部材５０として平行平面板を配置しているが、パワーを持ったレンズを用いてもよい。

【０１５５】以上の本発明のズームレンズ及びそれを有する電子撮像装置は例えば次のように構成することができる。

【０１５６】〔１〕　物体側より順に、負の屈折力を有する第１レンズ群と、正の屈折力を有する第２レンズ群と、正の屈折力を有する第３レンズ群よりなり、無限遠物点合焦時における広角端から望遠端への変倍に際して、前記第２レンズ群が物体側へのみ移動し、前記第３レンズ群が第２レンズ群との間隔を変化させつつ移動し、前記第２レンズ群は、物体側から順に、正レンズＬ２１、負レンズＬ２２、正レンズＬ２３、負レンズＬ２４にて構成され、前記第２レンズ群中の正レンズＬ２３又は負レンズＬ２４の少なくとも何れかのレンズは非球面を有し、かつ、以下の条件（１）を満足することを特徴とするズームレンズ。

【０１５７】

（１）　　$0.6 < R_{22R} / R_{21F} < 2.2$

ただし、R_{21F}、R_{22R}はそれぞれ第２レンズ群の正レンズＬ２１の物体側の面、第２レンズ群の負レンズＬ２２の像側の面の光軸上の曲率半径である。

【０１５８】〔２〕　像側に配される電子撮像素子と一体化されたことを特徴とする上記１記載ズームレンズ。

【０１５９】〔３〕　電子撮像素子の撮像面側に配されるズームレンズにおいて、前記ズームレンズは、物体側より順に、負の屈折力を有する第１レンズ群と、正の屈

折力を有する第２レンズ群と、正の屈折力を有する第３レンズ群よりなり、無限遠物点合焦時における広角端から望遠端への変倍に際して、前記第２レンズ群が物体側へのみ移動し、前記第３レンズ群が第２レンズ群との間隔を変化させつつ移動し、前記第２レンズ群は、物体側から順に、正レンズＬ２１、負レンズＬ２２、正レンズＬ２３、負レンズＬ２４にて構成され、前記第２レンズ群中の正レンズＬ２３又は負レンズＬ２４の少なくとも何れかのレンズは非球面を有し、かつ、以下の条件（２）、（３）、（４）を満足することを特徴とするズームレンズ。

【０１６０】

（２）　$0<(C_{24F}-C_{23R})\cdot L<1.6$

（３）　$0.01<d_{23}/L<0.2$

（４）　$-0.4<L/f_{2R}<0.8$

ただし、$C_{23R}=1/R_{23R}$、$C_{24F}=1/R_{24F}$ であり、ここで、R_{23R}、R_{24F} はそれぞれ第２レンズ群の正レンズＬ２３の像側の面、第２レンズ群の負レンズＬ２４の物体側の面の光軸上の曲率半径、Ｌは撮像素子の有効撮像領域（略矩形）の対角長（ｍｍ）、d_{23}は第２レンズ群の正レンズＬ２３と負レンズＬ２４との光軸上の空気間隔、f_{2R}は第２レンズ群の正レンズＬ２３と負レンズＬ２４との合成焦点距離である。

【０１６１】〔４〕　像側に配される電子撮像素子と一体化され、かつ、以下の条件（２）、（３）、（４）を満足することを特徴とする上記１記載のズームレンズ。

【０１６２】

（２）　$0<(C_{24F}-C_{23R})\cdot L<1.6$

（３）　$0.01<d_{23}/L<0.2$

（４）　$-0.4<L/f_{2R}<0.8$

ただし、$C_{23R}=1/R_{23R}$、$C_{24F}=1/R_{24F}$ であり、ここで、R_{23R}、R_{24F} はそれぞれ第２レンズ群の正レンズＬ２３の像側の面、第２レンズ群の負レンズＬ２４の物体側の面の光軸上の曲率半径、Ｌは撮像素子の有効撮像領域（略矩形）の対角長（ｍｍ）、d_{23}は第２レンズ群の正レンズＬ２３と負レンズＬ２４との光軸上の空気間隔、f_{2R}は第２レンズ群の正レンズＬ２３と負レンズＬ２４との合成焦点距離である。

【０１６３】〔５〕　前記第２レンズ群の正レンズＬ２１と負レンズＬ２２とが接合されていることを特徴とする上記２から４の何れか１項記載のズームレンズ。

【０１６４】〔６〕　前記第２レンズ群が以下の条件（５）を満足することを特徴とする上記２から５の何れか１項記載のズームレンズ。

【０１６５】

（５）　$25<\nu_{21}-\nu_{22}+\nu_{23}-\nu_{24}<55$

ただし、ν_{21}、ν_{22}、ν_{23}、ν_{24}はそれぞれ第２レンズ群の正レンズＬ２１、負レンズＬ２２、正レンズＬ２３、負レンズＬ２４の媒質のアッベ数（ｄ線基準）である。

【０１６６】〔７〕　前記第２レンズ群における正レンズＬ２３又は負レンズＬ２４の少なくとも何れかに配された前記非球面の少なくとも何れかが以下の条件（６）を満足することを特徴とする上記２から６の何れか１項記載のズームレンズ。

【０１６７】

（６）　$7.5\times10^{-3}\cdot L>|Asp2R|>|Asp21F|$

ただし、Asp21F、Asp2R はそれぞれ正レンズＬ２１の物体側の面、正レンズＬ２３又は負レンズＬ２４の面の光軸上での曲率半径を有する球面に対し、光軸からの高さが０．３Ｌでの非球面偏倚量、Ｌは撮像素子の有効撮像領域（略矩形）の対角長（ｍｍ）であり、正レンズＬ２１の物体側面が球面の場合は非球面偏倚量Asp21Fを０とする。

【０１６８】〔８〕　以下の条件（７）を満足することを特徴とする上記２から７の何れか１項記載のズームレンズ。

【０１６９】

（７）　$-0.5<(R_{21F}-R_{22R})/(R_{21F}+R_{22R})<0.3$

ただし、R_{21F}、R_{22R} はそれぞれ第２レンズ群の正レンズＬ２１の物体側の面と負レンズＬ２２の像側の面の光軸上の曲率半径である。

【０１７０】〔９〕　以下の条件（８）及び（９）を満足することを特徴とする上記２から８の何れか１項記載のズームレンズ。

【０１７１】（８）　$-1<f_3/f_{2R}<1.6$

（９）　$0.02<d_{22}/L<0.5$

ただし、f_{2R}とf_3 はそれぞれ第２レンズ群の正レンズＬ２３と負レンズＬ２４との合成焦点距離と第３レンズ群の焦点距離、d_{22}は第２レンズ群の負レンズＬ２２の像側面と正レンズＬ２３の物体側面との間隔、Ｌは撮像素子の有効撮像領域（略矩形）の対角長（ｍｍ）である。

【０１７２】〔１０〕　以下の条件（１０）を満足する上記１乃至９の何れか１項に記載のズームレンズ。

【０１７３】（10）　$-1<f_{2F}/R_{21R}<2.5$

ただし、R_{21R} は第２レンズ群の正レンズＬ２１の像側の面の曲率半径、f_{2F}は第２レンズ群の正レンズＬ２１と負レンズＬ２２との合成焦点距離である。

【０１７４】〔１１〕　広角端から望遠端に変倍する際、前記第３レンズ群は像側に凸の軌跡で移動することを特徴とする上記１から１０の何れか１項記載のズームレンズ。

【０１７５】〔１２〕　前記第３レンズ群を光軸に沿って移動することにより合焦することを特徴とする上記１から１１の何れか１項記載のズームレンズ。

【０１７６】〔１３〕　広角端半画角ω_Wが２７°から

４２°の範囲にあることを特徴とする上記１から１２の何れか１項記載のズームレンズ。

【０１７７】〔１４〕　上記１から１３の何れか１項記載のズームレンズを備えたことを特徴とする電子撮像装置。

【０１７８】

【発明の効果】本発明により、沈胴厚が薄く収納性に優れ、かつ、高倍率でリアフォーカスにおいても結像性能の優れたズームレンズを得ることができ、ビデオカメラやデジタルカメラの徹底的薄型化を図ることが可能となる。

【図面の簡単な説明】

【図１】本発明の電子撮像装置に用いられるズームレンズの実施例１の無限遠物点合焦時の広角端（ａ）、中間状態（ｂ）、望遠端（ｃ）でのレンズ断面図である。

【図２】実施例２のズームレンズの図１と同様のレンズ断面図である。

【図３】実施例３のズームレンズの図１と同様のレンズ断面図である。

【図４】実施例４のズームレンズの図１と同様のレンズ断面図である。

【図５】実施例５のズームレンズの図１と同様のレンズ断面図である。

【図６】実施例６のズームレンズの図１と同様のレンズ断面図である。

【図７】実施例７のズームレンズの図１と同様のレンズ断面図である。

【図８】実施例８のズームレンズの図１と同様のレンズ断面図である。

【図９】実施例９のズームレンズの図１と同様のレンズ断面図である。

【図１０】実施例１０のズームレンズの図１と同様のレンズ断面図である。

【図１１】実施例１の無限遠物点合焦時の収差図である。

【図１２】実施例１の被写体距離１０ｃｍ合焦時の収差図である。

【図１３】本発明のおける非球面偏倚量の定義を説明するための図である。

【図１４】電子撮像素子にて撮影を行う場合の有効撮像面の対角長について説明するための図である。

【図１５】近赤外シャープカットコートの一例の透過率特性を示す図である。

【図１６】ローパスフィルターの射出面側に設ける色フィルターの一例の透過率特性を示す図である。

【図１７】補色モザイクフィルターの色フィルター配置を示す図である。

【図１８】補色モザイクフィルターの波長特性の一例を示す図である。

【図１９】本発明によるズームレンズを組み込んだデジタルカメラの外観を示す前方斜視図である。

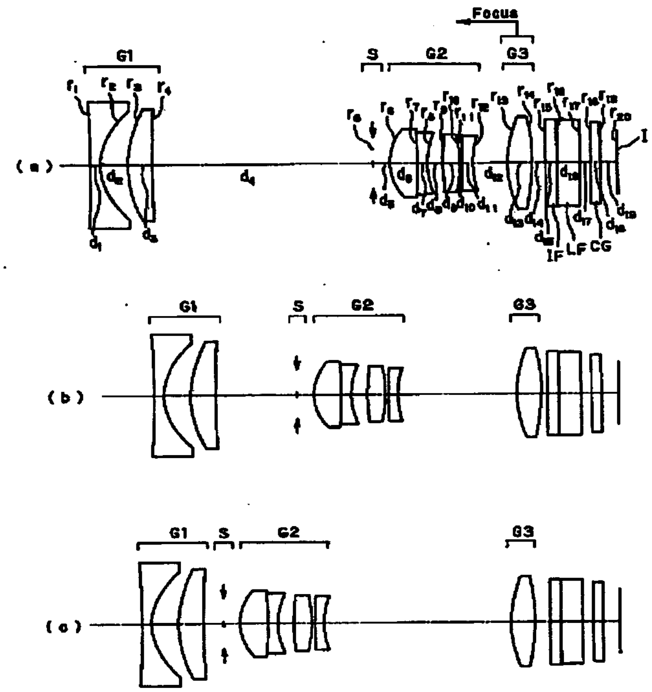
【図２０】図１９のデジタルカメラの後方斜視図である。

【図２１】図１９のデジタルカメラの断面図である。

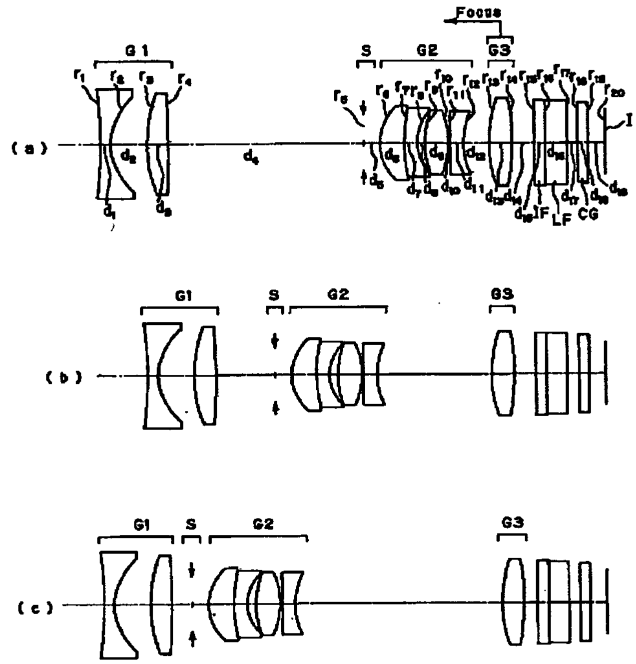
【符号の説明】

Ｇ１…第１レンズ群
Ｇ２…第２レンズ群
Ｇ３…第３レンズ群
Ｓ…開口絞り
ＩＦ…赤外カット吸収フィルター
ＬＦ…ローパスフィルター
ＣＧ…カバーガラス
Ｉ…像面
Ｅ…観察者眼球
４０…デジタルカメラ
４１…撮影光学系
４２…撮影用光路
４３…ファインダー光学系
４４…ファインダー用光路
４５…シャッター
４６…フラッシュ
４７…液晶表示モニター
４９…ＣＣＤ
５０…カバー部材
５１…処理手段
５２…記録手段
５３…ファインダー用対物光学系
５５…ポロプリズム
５７…視野枠
５９…接眼光学系

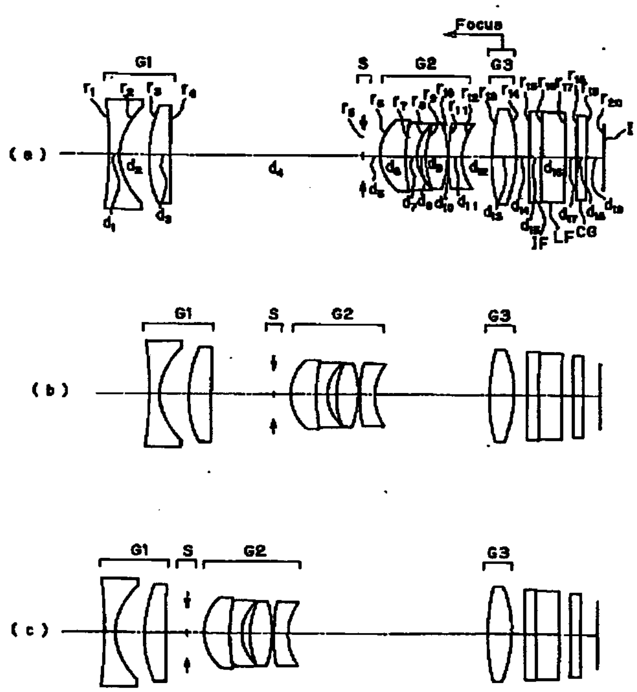
【図１】


Focus
G1
S
G2
G3
(a)
(b)
(c)
IF
LF
CG
I

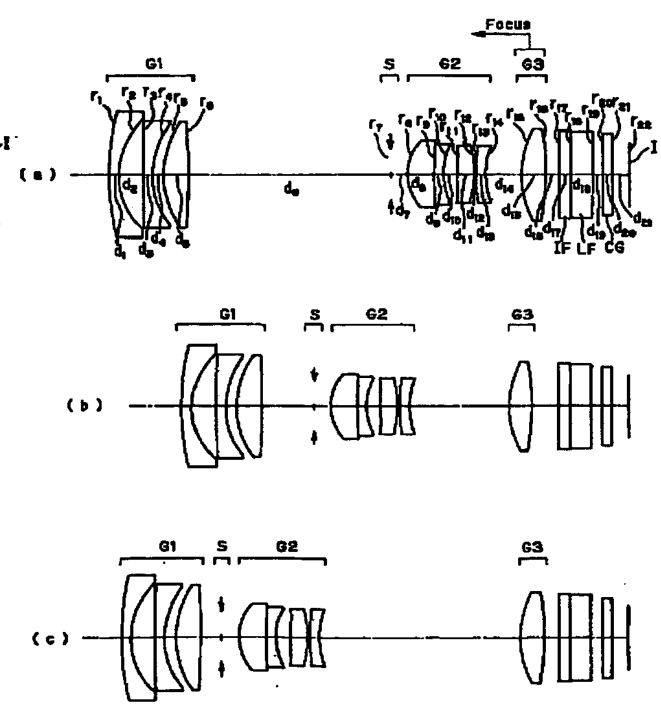
【図２】


Focus
G1
S
G2
G3
(a)
(b)
(c)
IF
LF
CG
I

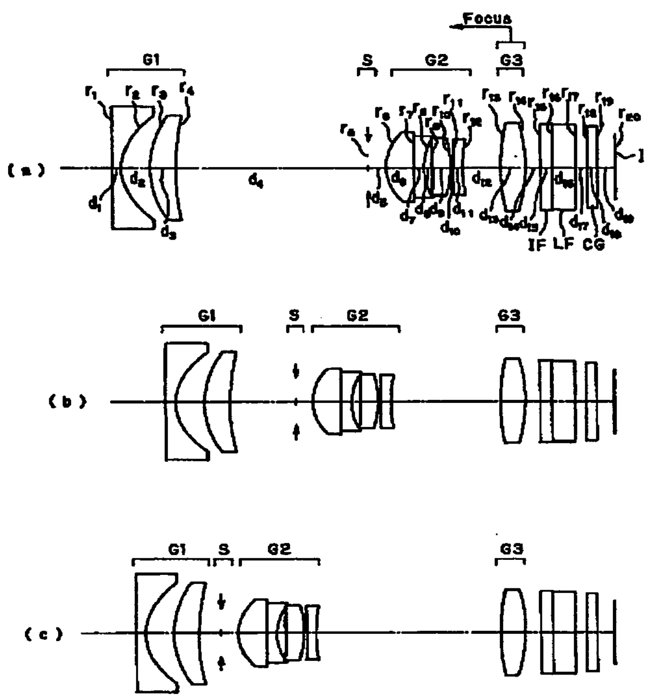
【図３】


Focus
G1
S
G2
G3
(a)
(b)
(c)
IF
LF
CG
I

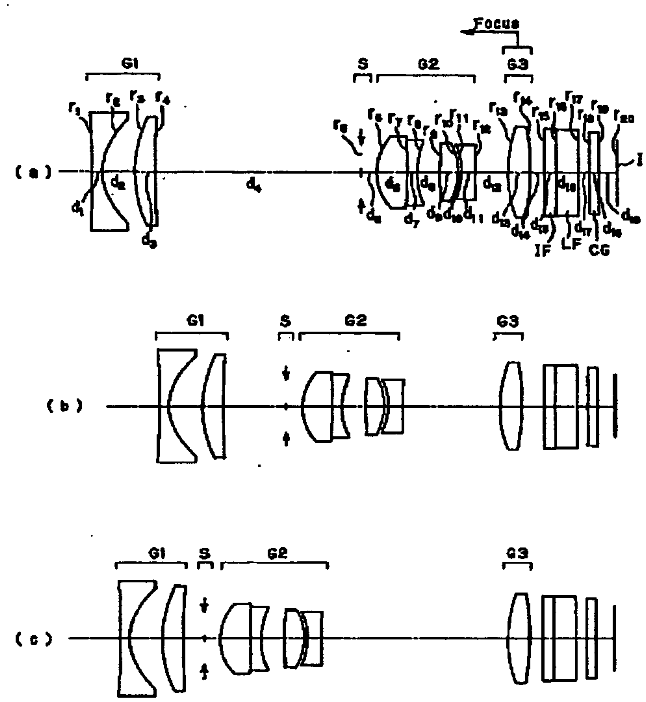
【図４】


Focus
G1
S
G2
G3
(a)
(b)
(c)
IF
LF
CG
I

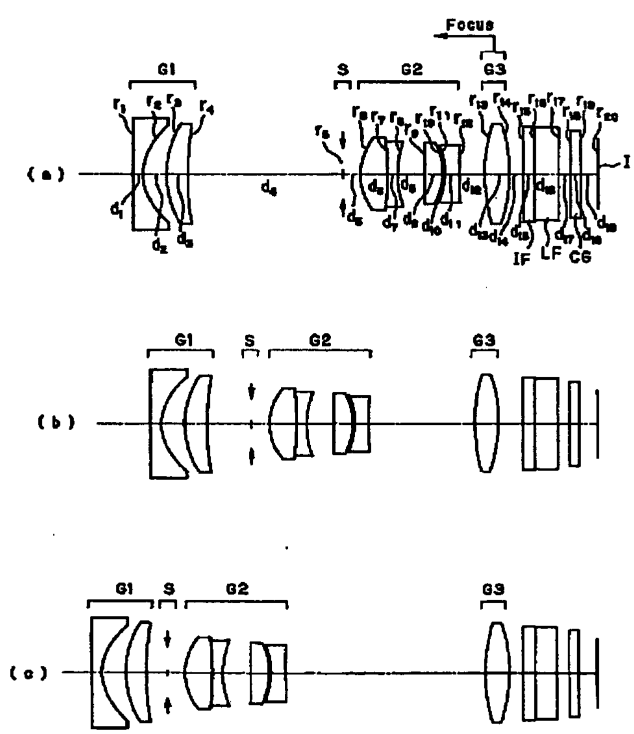
【図５】


Focus
G1
S
G2
G3
(a)
(b)
(c)
IF
LF
CG
I

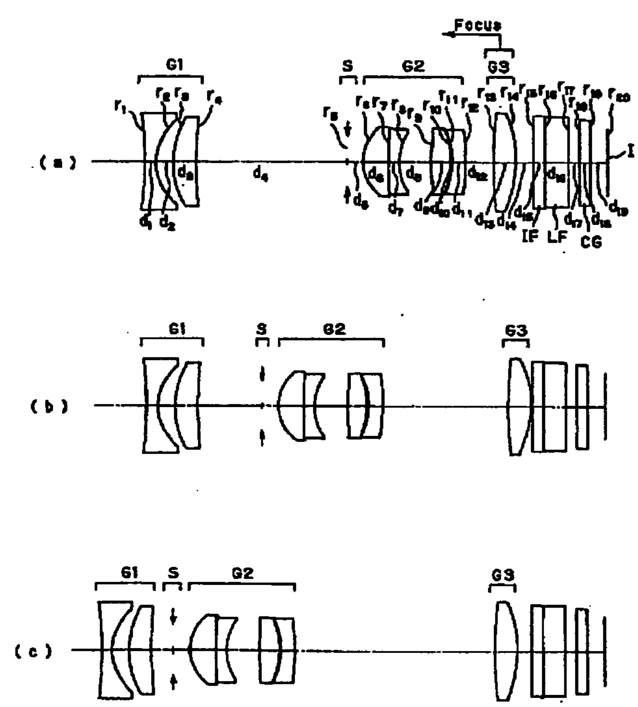
【図６】


Focus
G1
S
G2
G3
(a)
(b)
(c)
IF
LF
CG
I

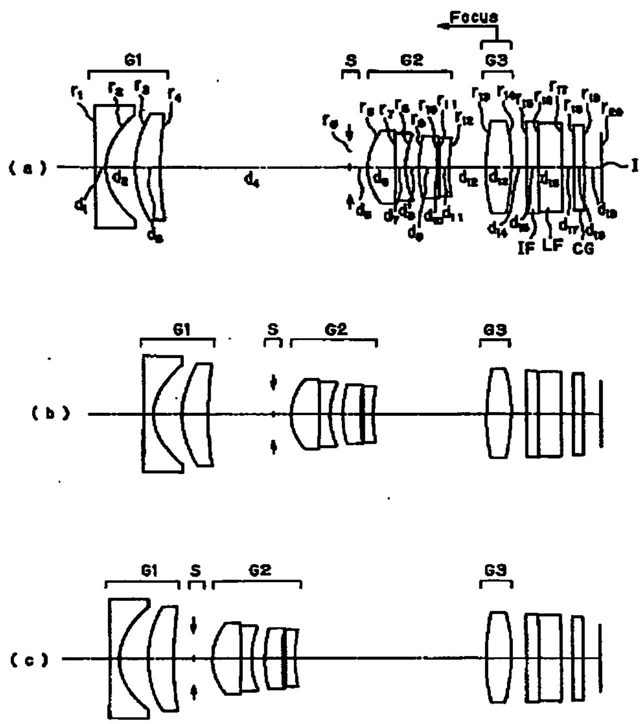
【図７】


Focus
G1
S
G2
G3
(a)
(b)
(c)
IF
LF
CG
I

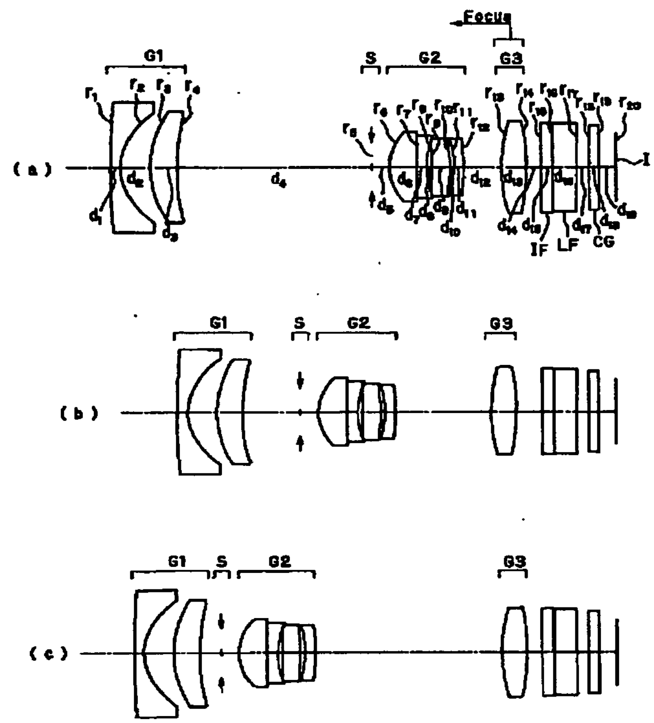
【図８】


Focus
G1
S
G2
G3
(a)
(b)
(c)
IF
LF
CG
I

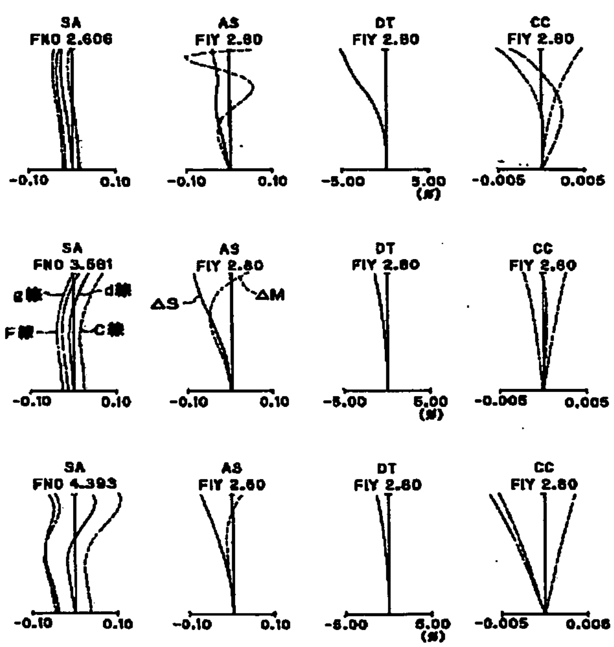
【図９】



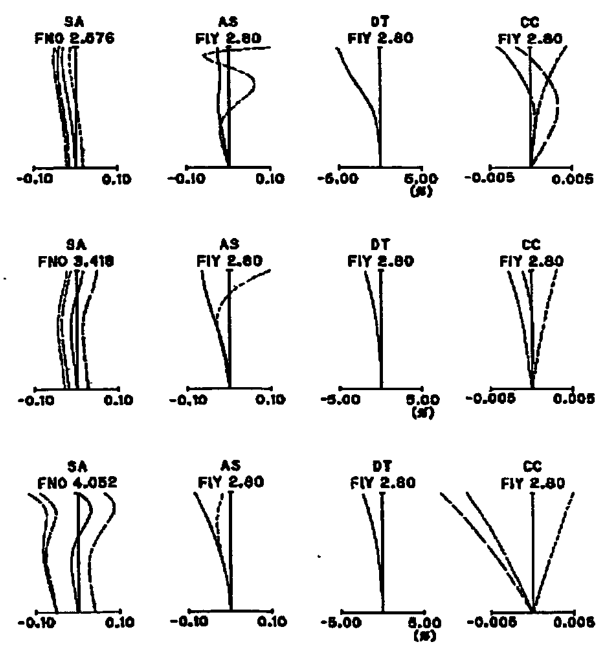
【図１０】



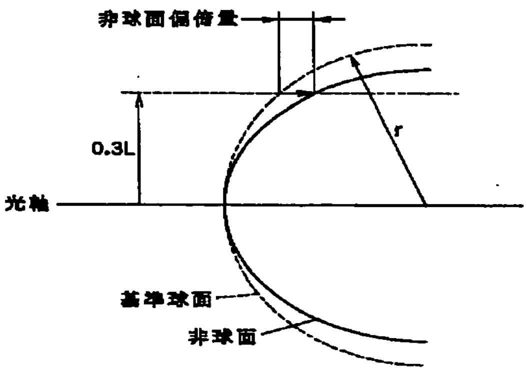
【図１１】



【図１２】



【図１３】



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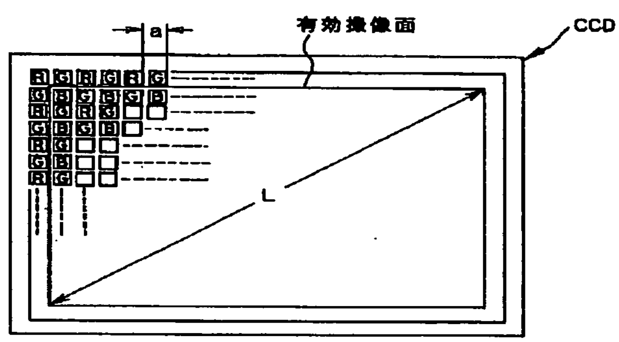

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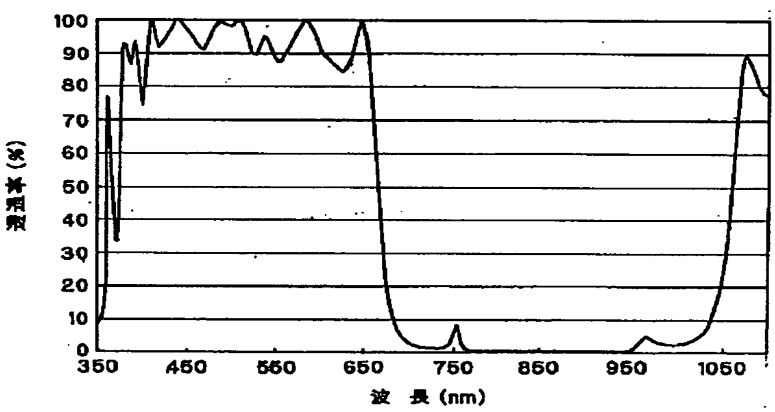

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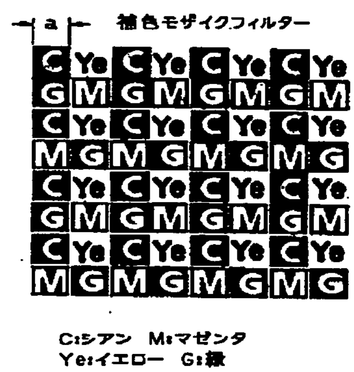

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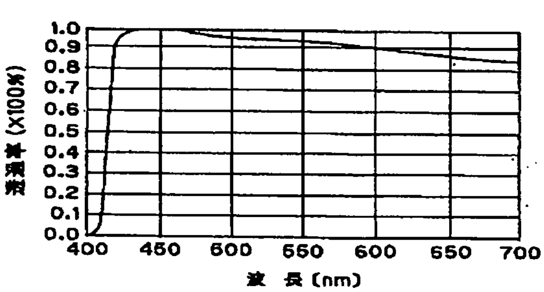

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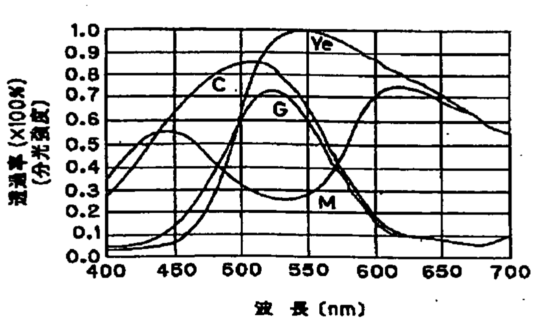

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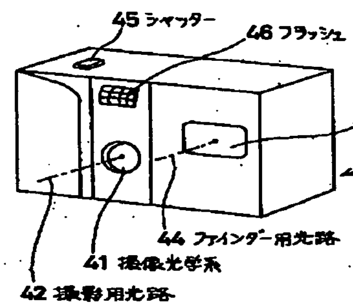

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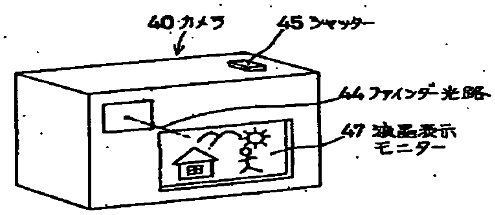

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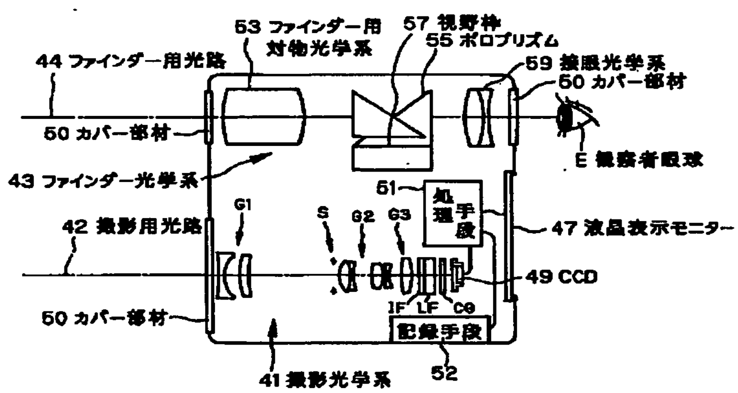

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